Scap OU 3

7/19/94 ROD

AR indices in Sec II

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Naval Submarine Base, Bangor
Operable Unit 4
Silverdale, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected action for Operable Unit 4 (OU 4) at the Naval Submarine Base (SUBASE), Bangor in Silverdale, Washington, chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practical, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). OU 4 consists of two sites: Sites C-East and C-West, which are contiguous. The no-action alternative was chosen because human health and environmental risks calculated for the sites are within the United States Environmental Protection Agency's (EPA's) acceptable risk range. This decision is based on the administrative record for these sites.

The lead agency for this decision is the United States Navy. The EPA approves of this decision and, with the Washington State Department of Ecology (Ecology), has participated in scoping the site investigations and in evaluating alternatives for remedial action. The State of Washington concurs with this decision.

DESCRIPTION OF THE REMEDY

The no-action alternative has been chosen for Sites C-East and C-West.

DECLARATION

No remedial action is necessary to ensure protection of human health and the environment. No further monitoring or investigative studies will be conducted. A 5-year review is not required.

The Navy used EPA guidelines and the information developed during the remedial investigation to evaluate the potential adverse effects on human health and the environment associated with exposure to site chemicals. The potential exposure of workers and residents to chemicals detected at each site was estimated for current and future scenarios. The evaluation, performed according to EPA's National Contingency Plan and policy guidance, indicated that no action is necessary to be protective to human health and the environment and that calculated risks from exposure to chemicals detected at the sites are within the EPA's acceptable risk range.

Signature sheet for the foregoing SUBASE, Bangor Operable Unit 4, Remedial Action, Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

E R Lockwood

Captain Ernest R. Lockwood
SUBASE, Bangor Commanding Officer
United States Navy

6/17/94
Date

Signature sheet for the foregoing SUBASE, Bangor Operable Unit 4, Remedial Action, Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Chuck Clarke

Chuck Clarke
Regional Administrator, Region 10
United States Environmental Protection Agency

7/19/94
Date

Signature sheet for the foregoing SUBASE, Bangor Operable Unit 4, Remedial Action, Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Carol Kraege

Carol Kraege, Acting Program Manager
Toxics Cleanup Program
Washington State Department of Ecology

6/27/94
Date

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ABBREVIATIONS AND ACRONYMS

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cfs	cubic feet per second
COPC	chemical of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbons
CRQL	contract-required quantitation limit
EA	ecological assessment
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
EPC	exposure-point concentrations
FFA	Federal Facilities Agreement
FS	feasibility study
ft/ft	foot per foot
gm/L	grams per liter
gpm	gallons per minute
GW	groundwater
HEAST	Health Effects Assessment Summary Tables (database)
HI	hazard index
HQ	hazard quotient
IAS	initial assessment study
IGZ	intermediate groundwater zone
IRIS	Integrated Risk Information System (database)
MCL	maximum contaminant limit
mg/kg	milligram per kilogram
msl	mean sea level
NA	not applicable
NACIP	Navy Assessment and Control of Installation Pollutants
NAD	Naval Ammunition Depot
Navy	United States Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NPL	National Priorities List
NTS	Naval Torpedo Station

ABBREVIATIONS AND ACRONYMS (Continued)

NTU	nephelometric turbidity units
NUWES	Naval Undersea Warfare Engineering Station
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PGDN	propylene glycol dinitrate (Otto fuel)
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
RA	risk assessment
RDX	Royal Demolition Explosive (cyclonite or hexahydro-1,3,5-trinitro-1,3,5-triazine)
RfD	reference dose
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
SARA	Superfund Amendments and Reauthorization Act of 1986
SB	soil boring
SD	sediment
SF	slope factor
SS	surface soil
SUBASE	submarine base
SVOC	semivolatile organic compound
SW	surface water
TAL	target analyte list
TBC	to be considered
TCE	tetrachloroethene
TCL	target compound list
TIC	tentatively identified compounds
TNT	trinitrotoluene
UCL	upper confidence limit
UF	uncertainty factor
URS	URS Consultants, Inc.
μg/L	microgram per liter
VOC	volatile organic compound

DECISION SUMMARY

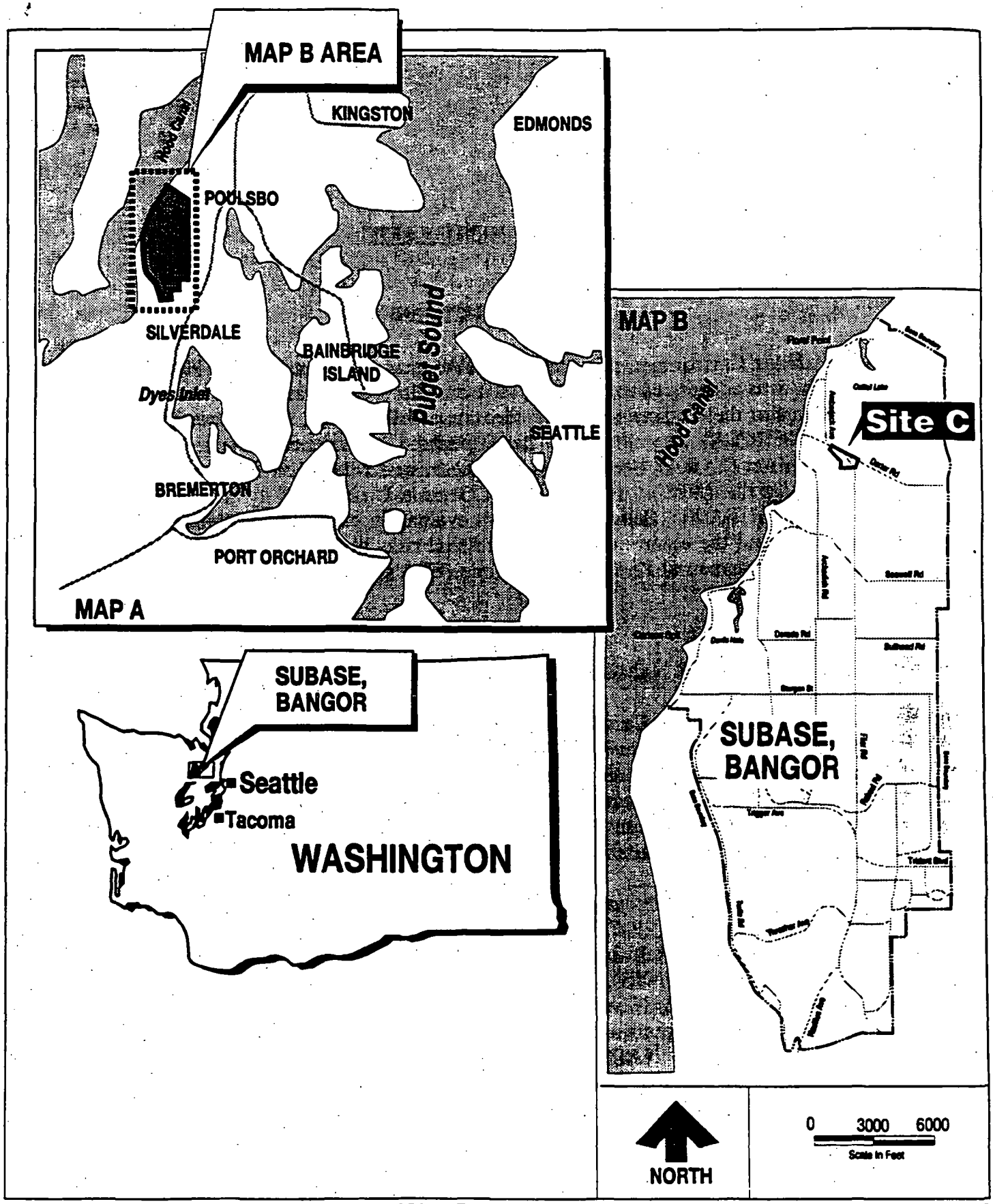
1.0 INTRODUCTION

Under the Defense Environmental Restoration Program, the United States Navy's (Navy's) policy is to address contamination at installations in a manner consistent with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), because the sites addressed have been listed on the National Priorities List (NPL). In the case of Operable Unit 4 (OU 4) at the Naval Submarine Base (SUBASE), Bangor, the Navy's evaluation of potential adverse effects on human health and the environment indicated that risks at the sites are within the United States Environmental Protection Agency's (EPA's) acceptable risk range for current and future uses.

2.0 SITE NAME, LOCATION, AND DESCRIPTION

SUBASE, Bangor is on Hood Canal, in Kitsap County, Washington, approximately 10 miles north of Bremerton (Figure 1). Land surrounding SUBASE, Bangor is generally undeveloped or supports limited residential use. Naval activities began at Bangor on June 4, 1944, when the United States Naval Magazine, Bangor was officially established as a Pacific shipment point for ammunition and explosives. When World War II ended, the Naval Complex became available for the storage of ordnance.

On August 10, 1945, the activity was officially commissioned as a U.S. Naval Magazine Facility, and, on December 1, 1947, the activity was redesignated the Naval Ammunition Depot (NAD), Bangor. Several times during its history NAD, Bangor was consolidated with Naval Torpedo Station (NTS), Keyport. In 1952, it returned to independent status and became the United States Naval Ammunition Depot (NAD), Bangor. During the late 1960s, conventional weapons used in the Vietnam War were loaded on ships from the Bangor Marginal Wharf. NAD, Bangor was responsible for about one-third of all Naval weapons sent to Vietnam from 1965 to 1970. In October 1970, NAD, Bangor was ordered disestablished and residual functions consolidated with Naval Torpedo Station (NTS), Keyport. No munitions were shipped from NTS, Keyport between 1970 and early 1972. When bombing runs were stepped up in Vietnam, NAD, Bangor returned to active status. The last shipment to Vietnam was loaded in January 1973.



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 1** **Site Location and Geographic Setting**	CTO 0039 Operable Unit 4 SUBASE, Bahgor Washington RECORD OF DECISION

On November 29, 1973, the Secretary of the Navy announced that the Bangor Naval complex had been selected as the West Coast home port for the Trident Submarine Launched Ballistic Missile System. SUBASE, Bangor was commissioned in February 1977, and the first submarine arrived in August 1982.

In July 1987, Site A, located at the northern end of the base, was listed on the EPA's National Priorities List (NPL) of hazardous waste sites. On August 30, 1990, the remainder of the SUBASE, Bangor facility was listed on the NPL.

3.0 SITE HISTORY

Located in the northern portion of SUBASE, Bangor OU 4 is composed of Sites C-East and C-West, collectively referred to as Site C (Figure 2). Site C-East is the former disposal area for demilitarized ordnance wastewater and sludge. Site C-West contains the only permanent structure on Site C, Building 7700. Site C-East is at the intersection of Flier, Darter, and Pogy Roads. Site C-West is west of Site C-East, along Flier Road. During construction of Building 7700, a portion of a leachate disposal pit at Site C-East was used as fill material. The fill material was thought to be contaminated with ammonium picrate and was excavated and moved near its original location. Confirmation sampling was performed at Site C-West to ensure that all potentially contaminated soil was taken back to Site C-East.

As reported in the initial assessment study (U.S. Navy 1983), wastewater and sludges produced during demilitarization activities at NAD, Bremerton Annex were periodically brought to Site C-East for disposal between 1946 and 1957. This disposition could not be independently confirmed during historical search efforts. The demilitarized waste was believed to include ammonium picrate and a variety of projectile dyes, including Alphazurine B, Alphazurine 2G, violet BG, crimson R, and wood yellow extra (U.S. Navy 1983). The wastewater and sludges were trucked to Site C-East and disposed of in two unlined leachate pits. The pits had been excavated in the relatively permeable Vashon Recessional Outwash sands and gravels.

Between 1957 and 1964, NAD, Bremerton Annex—now named Jackson Park—demilitarized approximately 4,000 projectiles. Demilitarization consisted of the removal of ordnance from the projectiles. The projectiles were steam cleaned to remove residual picric acid. The resulting wastewater, estimated at 1 million gallons (with an estimated

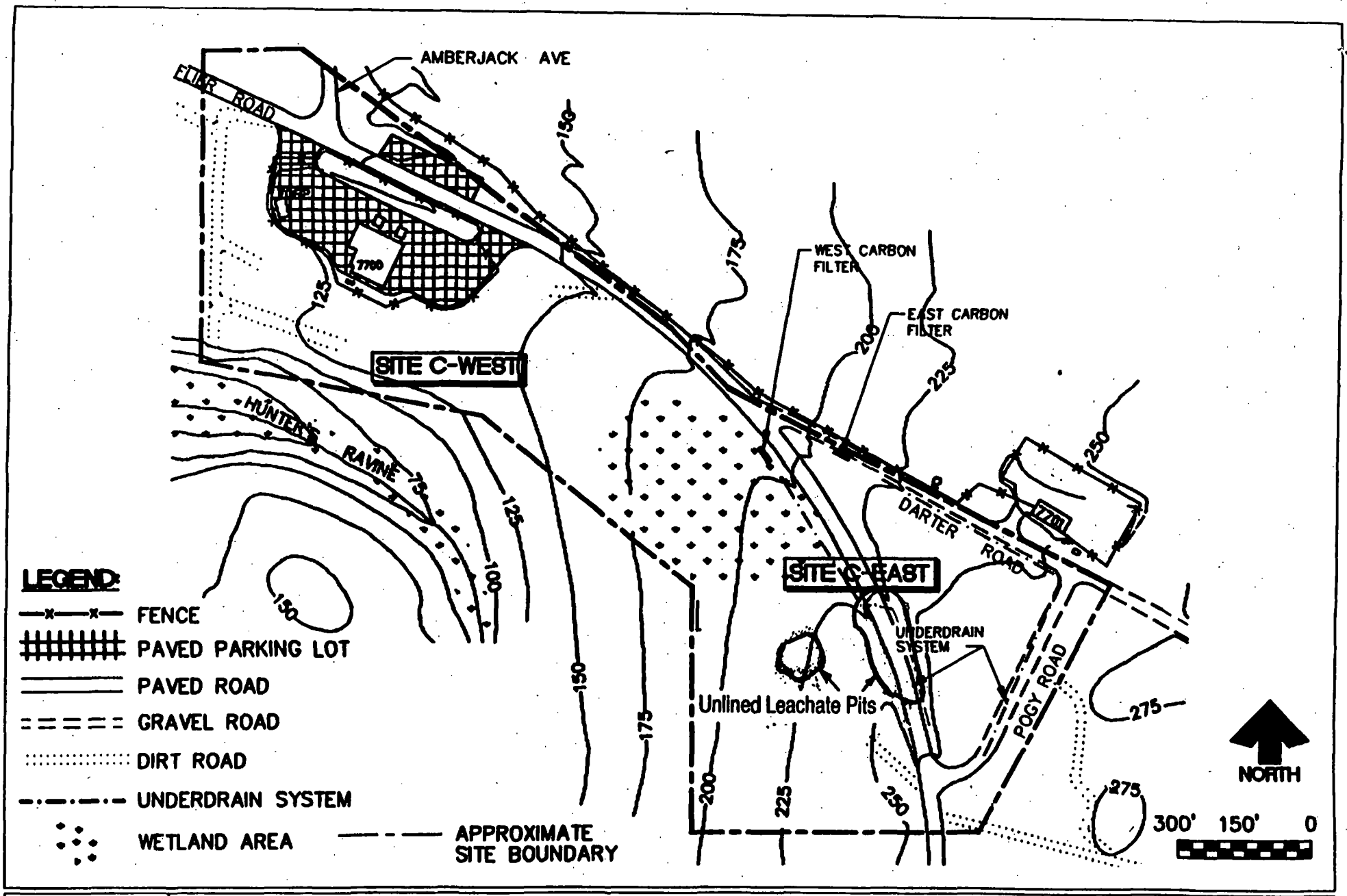


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Figure 2
Site C
Site Map

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concentration of 10 gm/L of picric acid), is believed to have been disposed of in the unlined leachate pits at Site C-East (Hart Crowser 1989).

From 1964 to 1971, Site C-East was inactive. In 1971, an oil-water separator was installed and the site was reopened for the treatment of wastewater contaminated with Otto (torpedo) fuel. The separator was adjacent to the leachate pit. The fuel waste removed from the wastewater by the separator was placed into storage containers. These containers were later removed from the site. The residual wastewater was then discharged from the separator onto the site. The location of the wastewater disposal area is unknown but it is assumed to be one or both of the pre-existing leachate pits. Documentation is not available on the oil-water separator's effectiveness during operation.

In 1977, a contractor excavated soils from the leachate disposal pit area while constructing Flier Road. Some of this excavated material was transported from Site C-East to Site C-West and used as fill. Shortly thereafter, during a wet period, yellow-tinted water was observed leaching from the fill material. Chemical analysis confirmed the presence of ammonium picrate and Otto fuel in the leachate. The material was removed from Site C-West and returned to Site C-East.

In 1978, a curtain drain, a road underdrain (collectively referred to as the underdrain system), and two carbon filter units were installed in Site C-East to treat surface water that had been contaminated. The locations of these filter units are shown on Figure 2. The carbon filter system was deactivated in December 1982 when influent concentration levels had fallen to low levels. Data analysis was conducted by the Navy at the Naval Undersea Warfare Engineering Station (NUWES), Keyport, Washington. Water samples were tested for Otto fuel, ammonium picramate, and ammonium picrate. The east carbon filter influent levels for the last 6 months of operation were 0.13 to 0.40 ppm for Otto fuel, less than 0.05 ppm for ammonium picramate, and less than 0.05 to 0.28 ppm for ammonium picrate. The west carbon filter had concentration levels of less than 0.001 to 0.62 ppm for Otto fuel and less than 0.05 ppm for ammonium picramate and ammonium picrate (URS 1993).

4.0 PHYSICAL CHARACTERISTICS OF OPERABLE UNIT 4

4.1 SURFACE WATER HYDROLOGY

4.1.1 Site C-East

At Site C-East, springs occur in the wetland area immediately west of Flier Road, where the perched aquifer surfaces near the surface drainage area are adjacent to Flier Road.

In 1978, an underdrain and a carbon filter system were installed at Site C-East (Figure 3). The carbon filters were removed from service in 1982, but the road subdrain is still present. On-site flows of surface water are intercepted by the underdrain system and are subsequently discharged northwest of Site C-East. According to previous investigations (Hart Crowser 1989), the streams discharging at this point appear to flow continuously during January through May at an average rate of 0.04 cubic feet per second (cfs).

4.1.2 Site C-West

The principal surface water drainage feature at Site C-West is an ephemeral stream that enters the site from the southeast (Figure 3). This drainage flows southwest near Building 7700 and then discharges into Hunter's Ravine. An ephemeral stream drainage west of Site C-West flows west to Hunter's Ravine.

Storm-related surface water discharges from Site C-East appear to be minor, indicating relatively high infiltration rates for the permeable near-surface soils. Much of Site C-West is paved, and flow is diverted to ditches or drains along Flier Road. Additionally, the low permeability Vashon Till is exposed at the surface in unpaved portions of Site C-West.

Small seeps were observed approximately 20 feet downslope in Hunter's Ravine south of Site C-West at the approximate locations shown on Figure 3. The flow rate from the seeps was visually estimated at 0.1 gallons per minute (gpm). The presence and location of seeps tend to confirm the stratigraphic interpretation that the shallow aquifer outcrops in the slope face of the ravine.

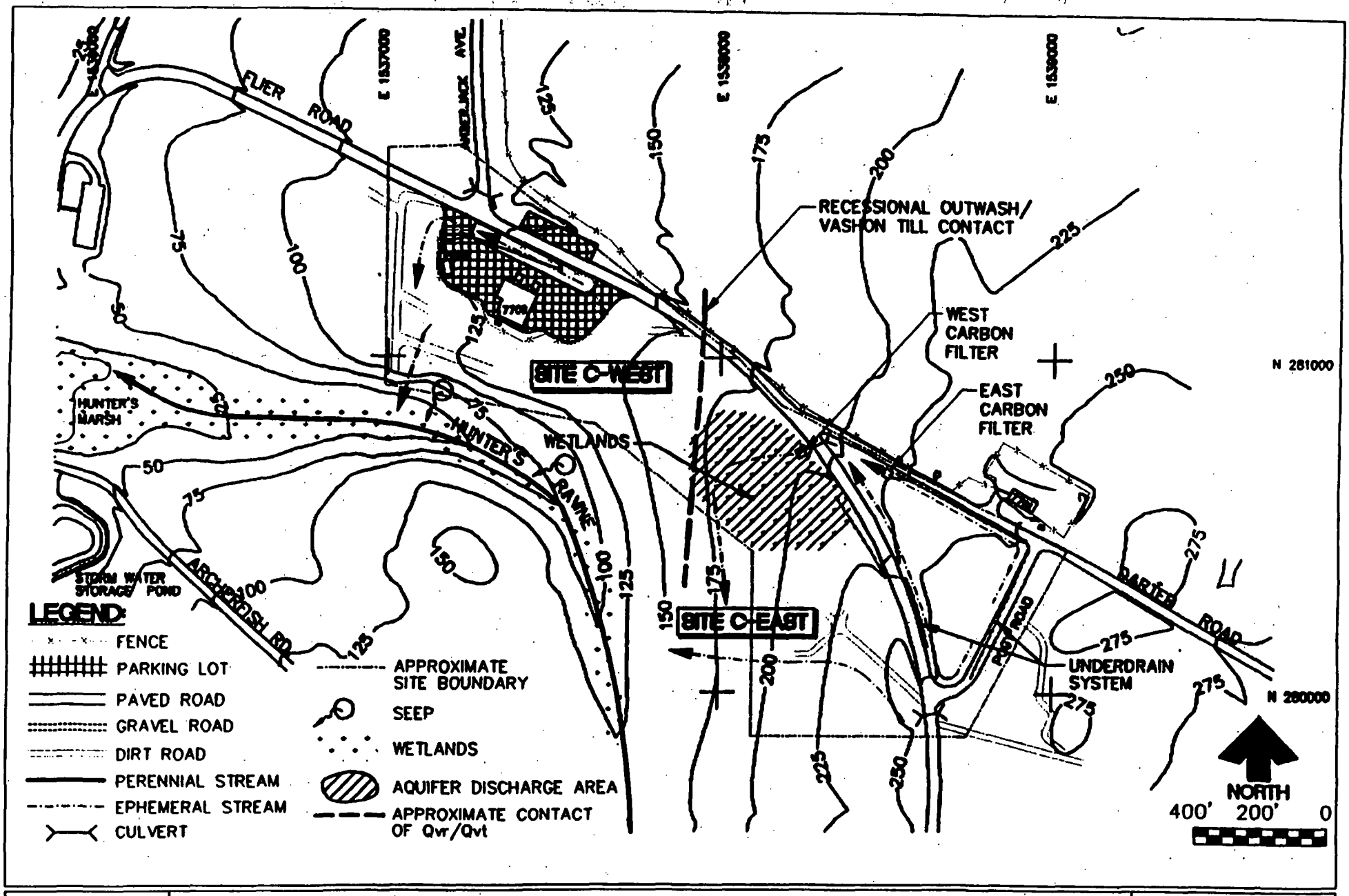

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Figure 3
Site C
Surface Water Drainage

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4.1.3 Stream Sediments

Upstream sediment samples at Site C-East consist of medium-brown, coarse-grained sand with gravel, silt, and minor organic debris. Downstream, where stream velocity decreases, sediments consist mostly of dark-brown, fine-grained, humic-rich material. Sediments along Flier and Darter Roads consist mostly of silt, with some sand and trace organics. The ephemeral stream sample west of Site C-West consists of dark-brown-to-black organic humus and silt. Samples from the wetland area at Site C-East consist of well-sorted sands with little organic material.

4.2 SITE HYDROGEOLOGY

Four geologic units have been identified at Site C. These units are the Vashon Recessional Outwash, Vashon Till, Vashon Advance Outwash, and the Kitsap Formation. The designation "Vashon" distinguishes those units deposited during the latest glacial advance. The Kitsap Formation is a lacustrine deposit that was formed during an interglacial period and is generally distinguished by high organic content.

The aquifers characterized through the RI/FS field activities at Sites C-East and C-West are the perched aquifer, found only at Site C-East, the shallow aquifer found at both Sites C-East and C-West, and the intermediate groundwater zones, found only at Site C-West. Groundwater flow direction for Site C is shown in Figure 4. The aquitards identified in the study areas are the Vashon Till, which separates the perched (where present) and shallow aquifers, and the Kitsap Formation, which underlies the shallow aquifer and hosts the intermediate groundwater zones. Although these units are generally characterized as aquitards, zones within the aquitards are composed of permeable, unstratified gravel, sand, and silt.

The site-specific characteristics of the geologic units encountered during remedial investigation (RI) field activities are described in Sections 4.2.1 through 4.2.4.

4.2.1 Vashon Recessional Outwash

The Vashon Recessional Outwash contains the perched aquifer in the shallow subsurface at Site C-East. This unit is not present at Site C-West. The contact between the Vashon Recessional Outwash and the Vashon Till surfaces in the wetland area separating Site C-East and Site C-West and represents the boundary of the wetland. The Vashon

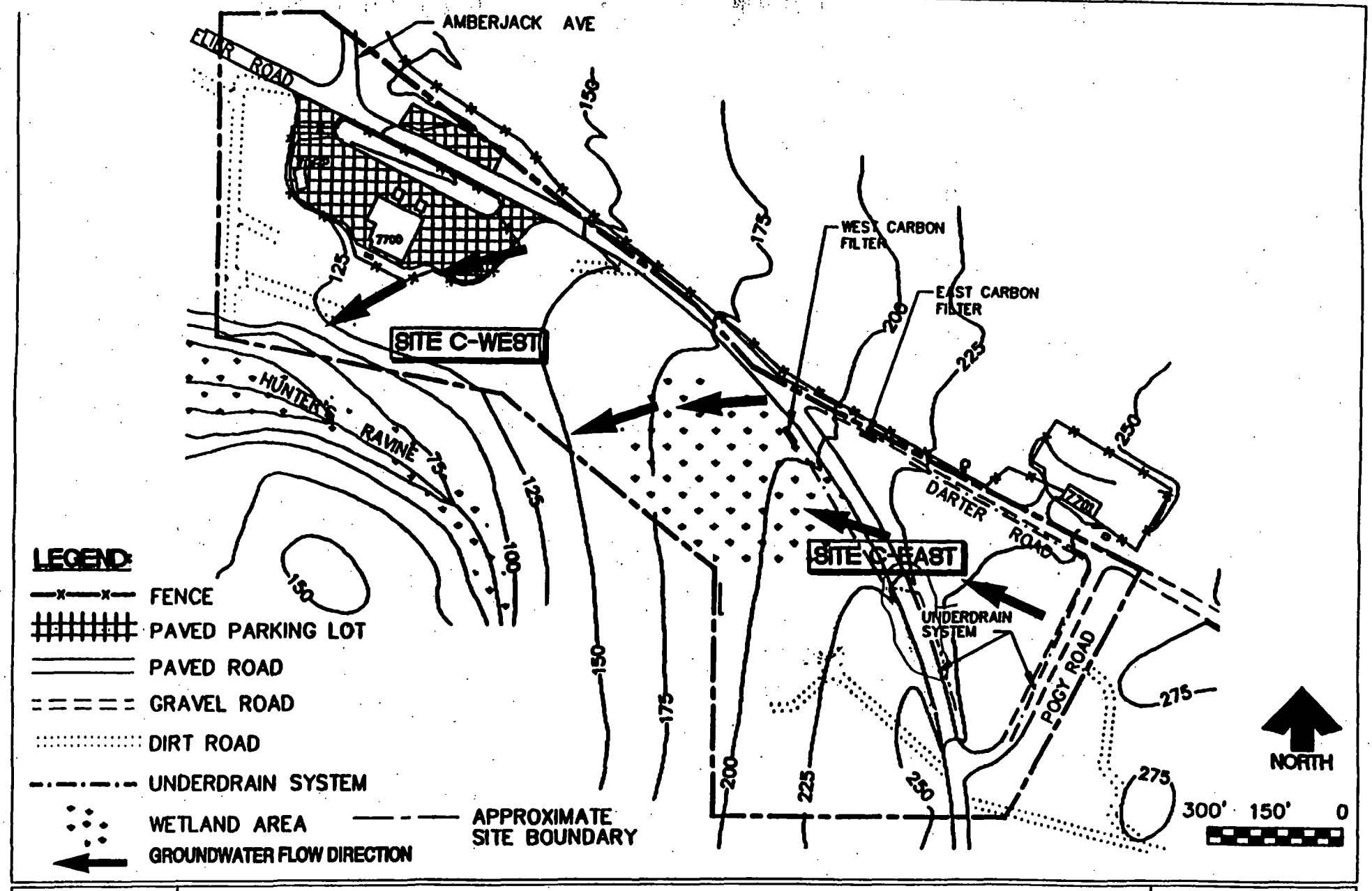

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Figure 4
Site C
Shallow Aquifer Groundwater Flow Direction

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Recessional Outwash ranges from approximately 10 feet to 30 feet in thickness in wells installed at Site C-East, with a perched aquifer saturated thickness ranging from 3 to 5 feet. The outwash material consists of a brown-to-gray unconsolidated fine-to-medium-grained silty sand with varying amounts of gravel.

Groundwater in the perched aquifer flows west to northwest. The water levels in the aquifer vary from approximately 3 feet below ground surface (bgs) during the seasonal low in September or October to 6 feet bgs during the seasonal high in February.

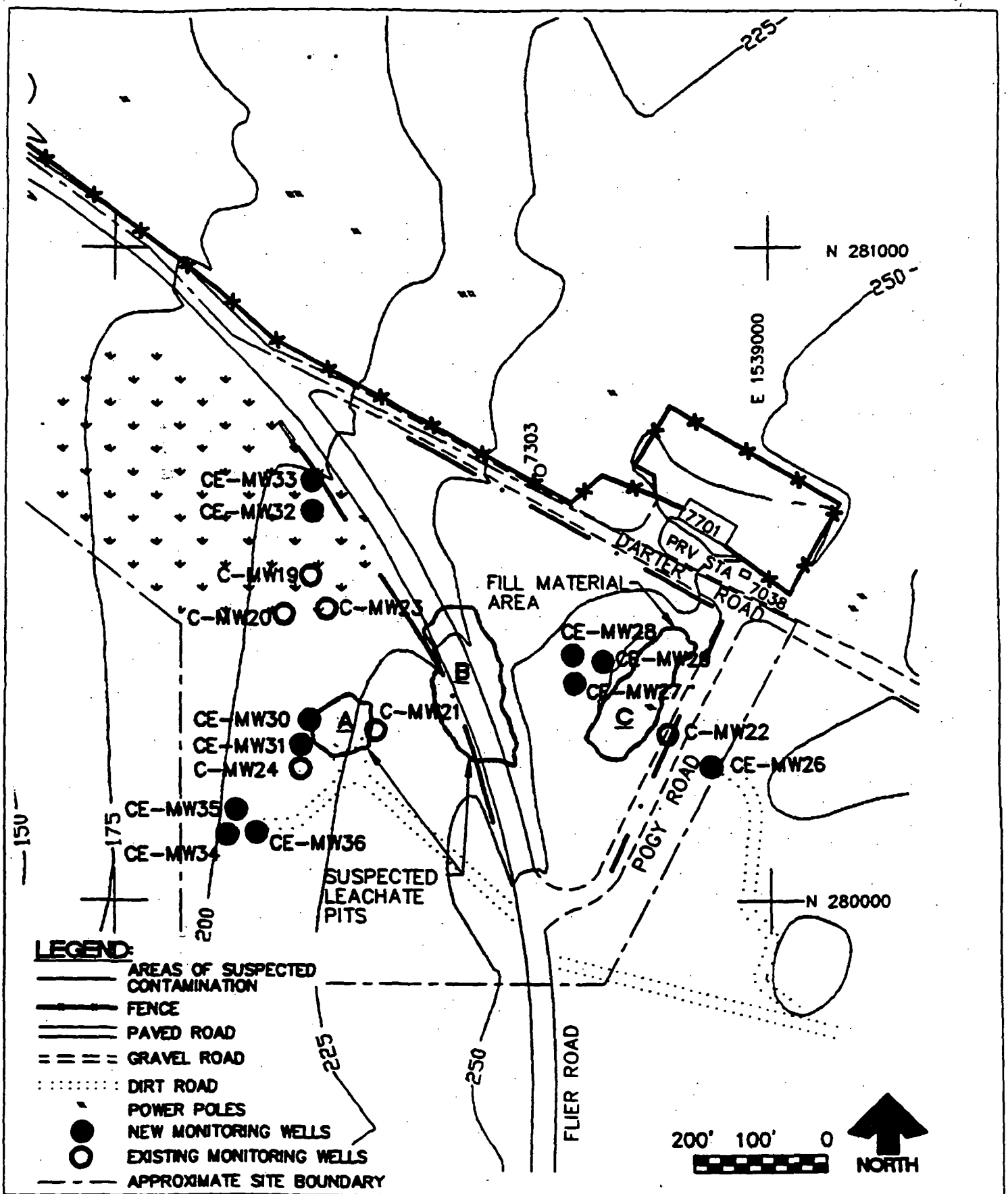
4.2.2 Vashon Till

The Vashon Till is immediately below the surface of Site C-West. At Site C-East, the Vashon Till underlies the Vashon Recessional Outwash. The Vashon Till varies from approximately 10 to 20 feet thick at Site C-East and from 25 to 50 feet thick at Site C-West. The till consists of a very dense to a dense, dry, poorly sorted mixture of sand, gravel, silt, and clay. Within the till are moist to wet zones of unconsolidated sand, silt, gravel, and peat.

The response of the water levels within the Vashon Till is similar to that of wells within the shallow aquifer, indicating possible interconnection. Groundwater levels vary up to 8 feet. The seasonal high is in February, and the seasonal low is in October.

4.2.3 Vashon Advance Outwash

Site C-East. The Vashon Advance Outwash is found beneath the Vashon Till at Site C-East. It ranges in thickness from approximately 45 to 90 feet. A lens containing peat, silt, and clay was observed within the Vashon Advance Outwash during drilling of wells in the Vashon Advance Outwash at Site C-East. This silt/peat lens ranges in thickness from less than 6 inches up to 20 feet and was encountered under portions of Site C-East. Lithology ranges from a peaty silt to a sandy silt with peat and to a sandy silt with minor interbeds of silt. The peat material in this lens consists of dark, carbon-rich plant material and woody fragments. The silt and peat lens was in the uppermost portion of the Vashon Advance Outwash at well CE-MW28/CE-MW29 (Figure 5) and was present as an interbed in the middle portion of the Advance Outwash at other areas of Site C-East. The silt/peat lens was not found at well CE-MW26 on the eastern portion of Site C-East. The peat/silt lens thins from east to west across Site C-East and is present only as interbeds at wells CE-MW32 and CE-MW33.



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 5** **Site C-East** **Monitoring Well Sample Locations**	CTO 0039 Operable Unit 4 SUBASE, Bangor Washington RECORD OF DECISION

A clay lens was observed at the bottom of well CE-MW36; it was identified as the Kitsap Formation at the time of drilling. Because of the differences in the elevation of the top of the Kitsap Formation observed at nearby wells, it has been identified as a clay lens and probably represents a gradational contact between the Vashon Advance Outwash and the Kitsap Formation. The extent of this clay layer is unknown.

Site C-West. The Vashon Advance Outwash lies below the Vashon Till at Site C-West and ranges in thickness from 10 to 17 feet. The Vashon Advance Outwash was encountered at elevations between 93 feet and 100 feet msl. At Site C-West, the Vashon Advance Outwash is composed primarily of gray to brown sandy silts and silty sands with varying amounts of gravel. Zones of silty, sandy gravels and sandy, gravelly silts were observed in the upper portion of the aquifer at wells CW-MW29 and CW-MW31 (Figure 6), which may represent a gradational contact between the Vashon Advance Outwash and the Vashon Till.

Using calculations from the January through December 1992 water level data, the potentiometric contours at Site C-West indicate approximate horizontal gradients ranging from 0.035 to 0.5 foot per foot (ft/ft) for the shallow aquifer. Gradients ranging from 0.029 to 0.036 ft/ft were calculated at Site C-West. A velocity of 18 feet per year was calculated for the shallow aquifer by using these gradients. These gradients indicate that groundwater flows northwest to west.

4.2.4 Kitsap Formation

At Site C-East, the Kitsap Formation lies below the Vashon Advance Outwash and is composed of a hard, dark-gray to blue-gray, silty clay to clayey silt with traces of sand and gravel. At Site C-West, the Kitsap Formation is composed of hard, blue-gray, silty clay to clayey silt and is layered with a hard, dry, brown, peaty silt and clay. The peat material is composed of carbon-rich plant material with woody fragments.

Three zones of sand, gravelly sand, and silty sand, ranging in thickness from approximately 3 to 30 feet, were encountered within the Kitsap Formation. These intermediate groundwater zones are the principal water-bearing unit in the Kitsap Formation.

At Site C-East, the Kitsap Formation was encountered at elevations ranging from 86 to 160 feet mean sea level (msl). At Site C-West, the Kitsap Formation was encountered at elevations ranging from 84 to 88 feet msl. The thickness of the Kitsap Formation at

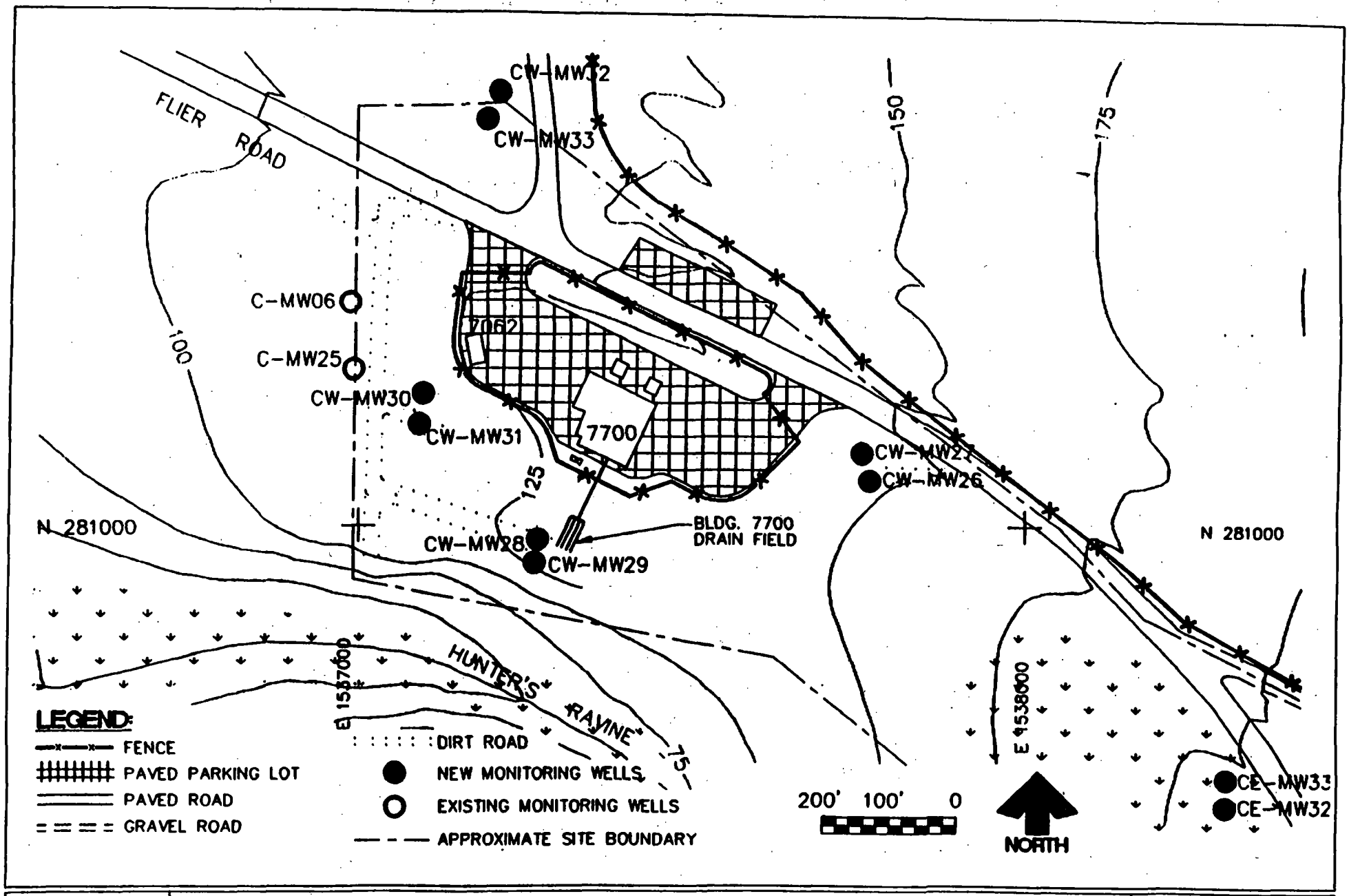


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Figure 6
Site C-West
Monitoring Well Locations

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Site C is unknown because no soil borings have completely penetrated the unit in this area. Site C-East borings for wells CE-MW29, CE-MW31, and CE-MW33 were drilled approximately 5 feet into the Kitsap Formation to verify contact between the Kitsap Formation and the shallow aquifer. At Site C-West, the Kitsap Formation-Vashon Advance Outwash contact was encountered in all of the borings drilled for the remedial investigation/feasibility study (RI/FS).

5.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

Community relations activities have established communication among citizens living near the site, the Navy, EPA, and Ecology. The actions taken to satisfy the requirements of federal regulations also provide a forum for citizen involvement and input to the remedial action decision.

A fact sheet, distributed to all persons on the mailing list in 1992, discussed all Federal Facility Agreement (FFA) sites, history, and RI activities at Sites C-East and C-West (OU 4).

The specific requirements for public participation pursuant to CERCLA §113 (k) (2) (b) and 117(a) as in 42 U.S.C. §9617 (2), as amended by SARA, include releasing the proposed plan for remedial action to the public. The proposed plan for remedial action was mailed to all known interested parties on November 1, 1993. One public comment received by the Navy concerned the proposed plan for remedial action at Operable Unit 4. It was submitted at the public meeting. The comment received and the agency response is in the Responsiveness Summary (Attachment 1). The *Proposed Plan for Remedial Action; Naval Submarine Base, Bangor—Operable Unit 4; Kitsap County, Washington* (Navy 1993) was placed in the administrative record and information repositories.

The administrative record is on file at:

Engineering Field Activity, Northwest
Naval Facility Command
1040 N.E. Hostmark Street
Olympic Place II
Poulsbo, Washington 98370
(206) 396-5984

The information repositories are located at:

Central Kitsap Regional Library
1301 Sylvan Way
Bremerton, Washington 98310
(206) 377-7601

SUBASE, Bangor Branch Library
Naval Submarine Base, Bangor
Bangor, Washington 98315
(Base access required)
(206) 779-9274

Notice of the availability of the proposed plan and notice of a public meeting on the proposed plan and public comment period were published in *The Sun* (Bremerton) on November 1, 1993, in the *Community Style* on November 3, 1993, in the north Kitsap *Herald* on November 3, 1993, and in the *Trident Tides* on November 5, 1993. A public comment period was held from November 1, 1993, to December 1, 1993. A public meeting was held on November 9, 1993, at the Olympic View Community Club in Silverdale, Washington. A total of 23 people attended.

6.0 SCOPE AND ROLE OF OPERABLE UNITS

Two NPL sites are at SUBASE, Bangor. The Bangor Ordnance Disposal Site A (OU 1) was listed on July 22, 1987. On August 30, 1990, the remainder of SUBASE, Bangor including an additional 6 operable units comprising 21 known or suspected hazardous waste sites, was listed. This Record of Decision addresses one of these operable units, OU 4. OU 4 consists of two sites, Sites C-East and C-West, which are contiguous.

OU 4 is the only operable unit at these sites and is upgradient of Site 26. Calculated human and environmental risks associated with both sites are within the EPA's acceptable risk range and do not warrant further remedial action.

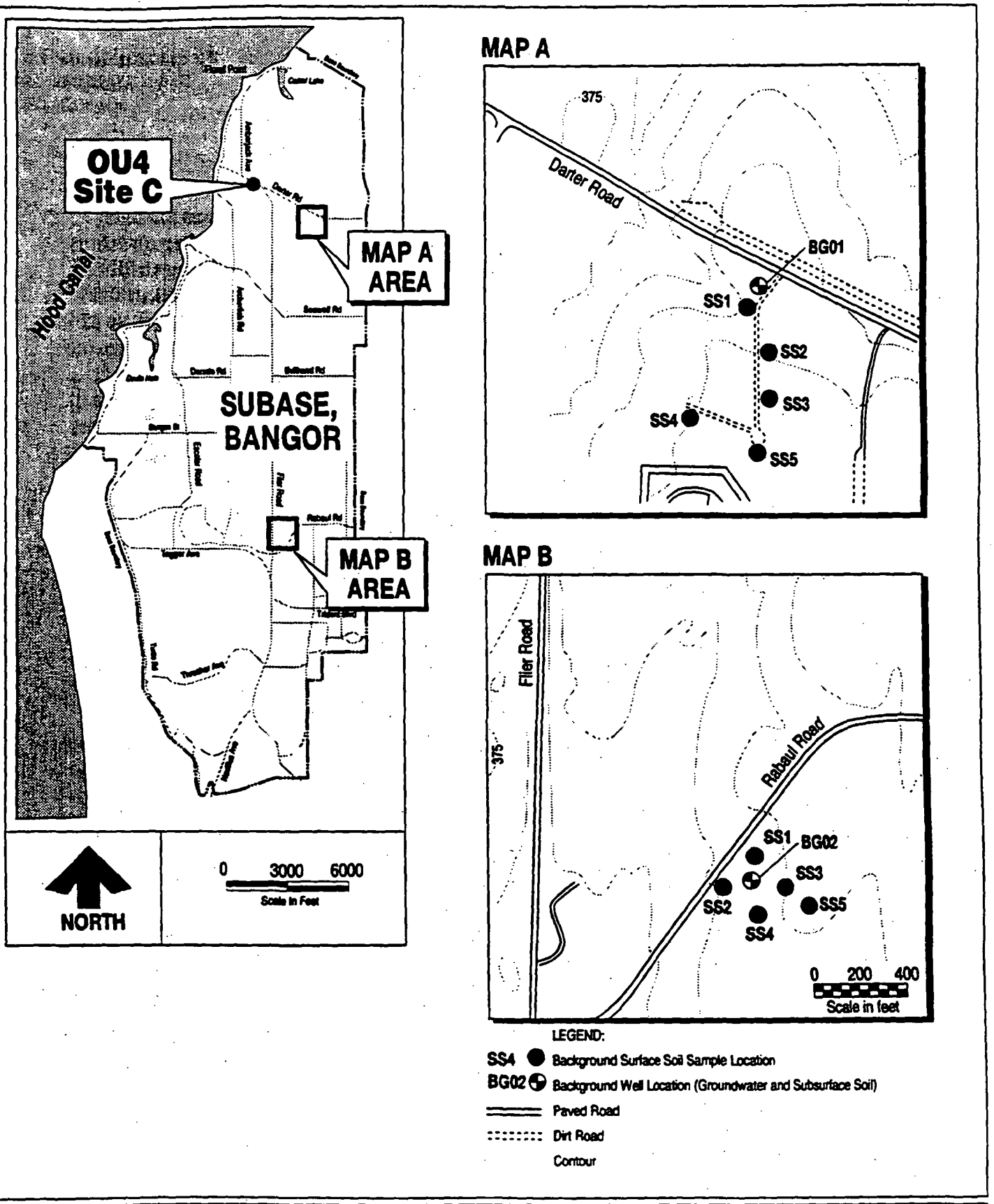
7.0 SUMMARY OF SITE CHARACTERISTICS

The Site C-East and C-West remedial investigation sampling activities included surface and subsurface soils, groundwater, and sediments. The analyses included ordnance, volatile organics, semivolatile organics, polychlorinated biphenyls (PCBs), organochlorine pesticides, all compounds from the EPA target compound list (TCL), all analytes from the EPA target analyte list (TAL), metals, and water quality parameters. Table 1 is a sample summary for all of Site C. Background sampling locations on the base were used to establish naturally occurring groundwater and soil metal levels. The established naturally occurring levels were used to compare to levels found at Site C-East and Site C-West. Background samples collected at SUBASE, Bangor included 10 surface soil, 50 subsurface soil, and 6 groundwater samples from the locations shown in Figure 7. Background samples were analyzed for TAL metals to establish natural background concentrations. Background concentrations for organic compounds were assumed to be zero.

Table 1
Sample Summary for Site C

Sample Type	Number of Samples Collected					
	Site C			Background		
	C-East	C-West	Total	BG01	BG02	Total
Total subsurface soils	109	111	220	28	20	48
Monitoring wells	69	47	116	28	20	48
Soil borings	40	54	94	-	-	-
Surface soils	30	18	48	5	5	10
Sediment[a]	6	15	21	-	-	-
Total groundwater[b]	54	19	73	3	3	6
Monitoring wells	44	19	63	3	3	6
Abandoned wells	10	-	10	-	-	-
Surface water	5	15	20	-	-	-

[a]Sample numbers include multiple sampling rounds.
[b]Analysis includes total and dissolved metals.
Note: This table does not include field duplicates, matrix spike/matrix spike duplicate, trip blanks, or rinsate samples.
- - not applicable



CLEAN COMPREHENSIVE LONG TERM ENVIRONMENTAL ACTION NAVY	**Figure 7** **Background Well and Subsurface Soil Locations**	CTO 0039 Operable Unit 4 SUBASE, Bangor Washington RECORD OF DECISION

Background Surface and Subsurface Soils Data. Background concentrations for each metal analyte were determined for surface soils and for each stratigraphic layer (Vashon Till, Vashon Advance Outwash, and the Kitsap Formation) encountered during drilling of the background wells BG01 and BG02. Data from 10 surface soil samples (0 to 0.5 feet) were used to determine the surface soil concentrations. Soil samples from 0 to 25 feet at BG01 and 0 to 52 feet at BG02 were used to determine metals concentrations of the Vashon Till. Soil samples from 30 to 142 feet at BG01 and from 60 to 222 feet at BG02 were used to determine metals concentrations of the Vashon Advance Outwash. Soil samples used to determine the metals concentrations of the Kitsap Formation were from 150 to 232 feet at BG01 and from 230 to 262 feet at BG02. Analytes that were undetected in a given sample were censored in accordance with MTCA (WAC 173-340-740[7][g]).

Metal concentrations in the subsurface soil differ between the geologic layers, with consistently higher concentrations in the Kitsap Formation than in the Vashon sequences. The high metals content in the Kitsap Formation may directly correlate with the high clay content and the basic provenance of the materials deposited during this period of time. Higher metals concentrations in groundwater samples from deeper monitoring wells reflect the influence of the Kitsap Formation.

Site soil samples were compared with respective background data. Four different strata were identified across Site C; however, only the Vashon Till, Vashon Advance Outwash, and Kitsap Formation can be compared with background data. The fill, Vashon Recessional Outwash, and peat layers encountered at Site C do not occur at the background sample locations; therefore, no background samples of these units are available.

Background Groundwater Data. Background groundwater concentrations for metals were determined from three rounds of sampling from monitoring wells BG01 and BG02. Background groundwater values were determined in a manner similar to that used for background soils data. First, the undetected values were censored in accordance with WAC 173-340-720(8)(g). These data were then evaluated for the distribution type (lognormal, normal, or neither), and the background values were determined, using the same criteria as soils. Because there are only two background wells, with three samples each, the data set is small. Therefore, when the calculated background value was greater than any of the observed values, the background value was reduced to the maximum observed value.

7.1 SITE C-WEST

Site C-West sample locations and results are presented in the following section along with the findings from the RI/FS. Tables 2 through 12 present the chemicals detected at the site for each medium compared to risk-based screening levels calculated by using the assumptions and procedures. These tables show exceedances of potential applicable or relevant and appropriate requirement (ARAR) and background. If no ARAR exists, then no exceedances were reported. If no background exists for a chemical, then the exceedance is for the ARAR only.

7.1.1 Surface Soil

A large portion of Site C-West was filled during the construction of Building 7700. The fill observed in the borings at Site C-West during the RI/FS subsurface investigation consisted of an orange to yellow, well-sorted sand. The fill ranged from 8 to 15 feet thick within the fenced area and from 3 to 4 feet thick outside the fence and southwest of Building 7700. The fill area extends approximately 200 feet southwest of the building, ending at the edge of the steep slope into Hunter's Ravine. Outside the fill area, the surface soil consists of a dark brown silty sand to sandy silt. Outside the paved areas, a layer of topsoil measuring from 1 to 5 feet deep contains various amounts of organic debris within the soil.

Surface soil samples were collected at Site C-West, outside the paved area, and three samples were collected from monitoring well locations CW-MW26, CW-MW30, and CW-MW32. These samples were then analyzed for ordnance, TCL volatile organics, semivolatile organics, pesticides, PCBs, and TAL metals.

The following findings are presented for surface soil sampling.

Metals. Beryllium was detected above screening criteria concentrations in 12 surface soil samples, with a maximum concentration of 0.96 milligram per kilogram (mg/kg). Manganese was detected above screening criteria in single surface soil samples, with a concentration of 1,040 mg/kg.

Organic Compounds. The volatile organic compounds (VOCs) detected included acetone, methylene chloride, 2-butanone, toluene, xylene, and ethylbenzene. All of these compounds were detected below screening criteria.

Table 2
Site C-West—Chemicals Detected in Surface Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	21	21	8,990	19,700	14,000	—	19,546	0
Arsenic	21	21	0.83	6.8	2.44	20	3.69	0
Barium	21	21	32.2	106	59	5,600	134	0
Beryllium	21	18	0.25	0.96	0.57	0.233	.49	12
Calcium	21	21	2,300	4,220	3,264	—	3,273	0
Chromium	21	21	19.5	48.8	27.7	400	34	0
Cobalt	21	21	5.6	12.4	8.42	4,800	7.75	0
Copper	21	21	6.6	15.8	11.2	2,960	16	0
Iron	21	21	9,800	22,300	14,742	—	16,958	0
Lead	21	21	1.4	16.4	5.3	—	31.8	0
Magnesium	21	21	2,040	5,530	3,839	—	4,033	0
Manganese	21	21	165	1,040	364	400	1,002	1
Nickel	21	21	21.9	51.3	36.8	1,600	63.3	0
Potassium	21	3	427	485	461	—	338	0
Silver	21	1	1.7	1.7	1.7	240	.97	0
Sodium	21	21	86.9	288	145	—	476	0
Vanadium	21	21	23.5	63.5	44	560	35.7	0
Zinc	21	21	18.2	40.6	26.9	22,400	38.4	0
Ordnance								
2,6-Dinitrotoluene	17	1	0.01343	0.01343	0.0134	1.47	•	0
Semivolatile Organics								
Benzoic acid	21	1	0.93	0.93	0.93	320,000	•	0
Pyrene	21	1	0.11	0.11	0.11	2,400	•	0
bis(2-ethylhexyl) phthalate	20	2	0.18	0.42	0.3	71.4	•	0
Volatile Organics								
2-Butanone	21	2	0.007	0.008	0.0075	48,000	•	0
Acetone	21	1	0.006	0.006	0.006	8,000	•	0
Ethylbenzene	21	12	0.004	0.026	0.0117	8,000	•	0
Methylene chloride	21	2	0.006	0.023	0.0145	133	•	0
Toluene	21	9	0.001	0.01	0.00578	16,000	•	0
Xylenes	21	9	0.002	0.007	0.00433	165,000	•	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
• - background established as zero

Table 3
Site C-West—Chemicals Detected in Construction Fill

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	31	31	7,610	20,300	10,854	—	0
Arsenic	31	30	1.1	14.4	1.87	20	0
Barium	31	31	31.9	64.4	43.6	5,600	0
Beryllium	31	17	0.24	0.53	0.382	0.233	17
Calcium	31	31	1,350	7,460	2,919	—	0
Chromium	31	31	18.3	70.5	25.6	400	0
Cobalt	31	31	6.1	12.6	7.95	4,800	0
Copper	31	31	5.1	20.3	10.8	2,960	0
Iron	31	31	9,840	24,600	13,101	—	0
Lead	31	31	1.2	6.3	2.16	—	0
Magnesium	31	31	2,820	9,340	4,647	—	0
Manganese	31	31	147	376	213	400	0
Nickel	31	31	25	72.3	39.6	1,600	0
Potassium	31	31	205	480	347	—	0
Sodium	31	31	70.7	189	136	—	0
Vanadium	31	31	23.5	82.2	34.5	560	0
Zinc	31	31	16.3	37.6	24.2	22,400	0
Ordnance							
2,4,6-Trinitrotoluene	33	2	.021	.1875	.104	33.3	0
2,4-Dinitrotoluene	33	1	.02971	.02971	.0297	1.47	0
Picric acid	31	1	0.0069	0.0069	0.0069	—	0
Semivolatile Organics							
Pyrene	31	1	.13	.13	.13	2,400	0
Bis(2-ethylhexyl) phthalate	31	9	.053	4.8	.666	71.4	0
Volatile Organics							
2-Butanone	31	3	.011	.042	.0243	48,000	0
Acetone	31	11	.011	.23	.0626	8,000	0
Methylene chloride	31	13	.001	.004	.00184	133	0
Toluene	31	1	.001	.001	.001	16,000	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 4
Site C-West—Chemicals Detected in the Vashon Recessional Outwash Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	44	44	5,280	94,600	12,557	—	0
Arsenic	44	44	0.59	4.8	1.69	20	0
Barium	44	44	19.5	104	41.2	5,600	0
Beryllium	44	25	0.24	0.95	0.514	0.233	25
Calcium	44	44	1,730	7,810	4,314	—	0
Chromium	44	44	14.2	53.9	26.4	400	0
Cobalt	44	44	5	19.6	9.34	4,800	0
Copper	44	44	2.7	50.5	15.6	2,960	0
Iron	44	44	7,410	31,200	14,604	—	0
Lead	44	44	0.78	7.5	2.06	—	0
Magnesium	44	44	2,600	13,100	5,381	—	0
Manganese	44	44	139	522	248	400	4
Nickel	44	43	21.3	91.1	41.6	1,600	0
Potassium	44	43	193	1,700	446	—	0
Sodium	44	44	85.9	1,510	314	—	0
Thallium	44	1	0.42	0.42	0.42	5.6	0
Vanadium	44	44	20.6	75.2	39.5	560	0
Zinc	44	44	17.8	74.8	27.6	22,400	0
Explosives							
RDX	42	2	0.02439	0.02567	0.025	9.09	0
Picramic acid	35	1	0.002	0.002	0.002	—	0
Picric acid	35	2	0.0053	0.0075	0.0064	—	0
Semivolatile Organics							
4-Methylphenol	42	1	0.23	0.23	0.23	4,000	0
Benzoic acid	42	1	0.14	0.14	0.14	320,000	0
Di-n-octylphthalate	43	3	0.14	0.17	0.156	1,600	0
Bis(2-ethylhexyl) phthalate	43	8	.082	1.5	.355	71.4	0
Volatile Organics							
2-Butanone	43	3	.007	.024	.014	48,000	0
Acetone	43	8	.004	.096	.028	8,000	0
Ethylbenzene	43	2	.002	.002	.002	8,000	0
Methylene chloride	43	4	.001	.001	.001	133	0
Toluene	43	1	.002	.002	.002	16,000	0
Xylenes	43	1	.001	.001	.001	165,000	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 5
Site C-West—Chemicals Detected in the Vashon Till Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	15	15	7,310	25,000	12,540	—	12,258	0
Arsenic	15	15	1.5	9.1	2.58	20	1.65	0
Barium	15	15	29	102	49.6	5,600	51.8	0
Beryllium	15	8	0.32	1.2	0.611	0.233	0.68	3
Calcium	15	15	3,880	14,500	6310	—	4,282	0
Chromium	15	15	19.3	55.5	29.7	400	26.6	0
Cobalt	15	15	7.3	26.8	12.5	4,800	10.6	0
Copper	15	15	10.5	70.2	25.7	2,960	24.4	0
Iron	15	15	11,900	52,800	21,700	—	15,816	0
Lead	15	15	1	16.4	4.13	—	1.97	0
Magnesium	15	15	4,350	12,200	7,588	—	6,415	0
Manganese	15	15	202	484	296	400	311	4
Mercury	15	2	0.15	0.47	0.31	24	0.08	0
Nickel	15	15	31.5	56.4	42.4	1,600	76.9	0
Potassium	15	15	384	1,750	748	—	490	0
Sodium	15	15	221	1,280	444	—	461	0
Vanadium	15	15	30.9	111	50.3	560	36.9	0
Zinc	15	15	21.9	90.2	40.2	22,400	31.5	0
Ordnance								
2,4,6-Trinitrotoluene	15	1	0.042	0.042	0.042	33.3	*	0
2,6-Dinitrotoluene	15	2	0.012	0.012	0.012	1.47	*	0
Semivolatile Organics								
Di-n-octylphthalate	15	2	0.1	0.24	0.17	1,600	*	0
bis(2-ethylhexyl) phthalate	15	1	0.18	0.18	0.18	71.4	*	0
Volatile Organics								
2-Butanone	15	2	0.004	0.011	0.0075	48,000	*	0
Acetone	15	5	0.002	0.05	0.018	8,000	*	0
Methylene chloride	15	2	0.001	0.001	0.001	133	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 6
Site C-West—Chemicals Detected in the Vashon Advance Outwash Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	21	21	10,800	27,700	17,371	—	14,094	0
Arsenic	21	20	1.2	12.1	3.53	20	5.1	0
Barium	21	21	19.4	108	48.3	5,600	76.6	0
Beryllium	21	11	0.61	1.4	0.961	0.233	0.58	11
Calcium	21	21	5,260	10,600	7,561	—	8,458	0
Chromium	21	21	28.7	58.2	38.8	400	41.8	0
Cobalt	21	21	11.2	20.7	16.4	4,800	14.7	0
Copper	21	21	18.4	60.2	38.6	2,960	29.4	0
Iron	21	21	17,600	38,500	28,776	—	22,928	0
Lead	21	21	1.6	13.3	5.74	—	3.94	0
Magnesium	21	21	6,570	14,400	9,502	—	13,460	0
Manganese	21	21	245	445	363	400	386	3
Mercury	21	1	0.16	0.16	0.16	24	0.06	0
Nickel	21	21	26.2	64.4	39.8	1,600	91.8	0
Potassium	21	18	291	1,980	788	—	1,236	0
Sodium	21	21	121	560	245	—	450.6	0
Vanadium	21	21	40.6	90.3	65	560	55.7	0
Zinc	21	21	45.7	89.7	62	22,400	46	0
Ordnance								
1,3,5-Trinitrobenzene	21	1	0.034	0.034	0.034	4	*	0
Nitrobenzene	21	1	0.031	0.031	0.031	40	*	0
Otto fuel	21	1	0.047	0.047	0.047	—	*	0
Semi-volatile Organics								
Di-n-butylphthalate	21	1	0.17	0.17	0.17	8,000	*	0
bis(2-Ethylhexyl) phthalate	21	2	0.14	0.15	0.145	71.4	*	0
Volatile Organics								
2-Butanone	21	12	0.002	0.029	0.01	48,000	*	0
Acetone	21	9	0.011	0.083	0.0381	8,000	*	0
Methylene chloride	21	9	0.001	0.007	0.003	133	*	0
Toluene	21	1	0.002	0.002	0.002	16,000	*	0
Xylenes	21	1	0.003	0.003	0.003	165,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 7
Site C-West—Chemicals Detected in the Intermediate Groundwater Zone Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	2	2	16,600	26,300	21,450	—	0
Arsenic	2	2	4.3	4.4	4.35	20	0
Barium	2	2	88.1	91.3	89.7	5,600	0
Beryllium	2	2	0.86	1.2	1.03	0.233	2
Calcium	2	2	6,460	7,790	7,125	—	0
Chromium	2	2	42.2	47.8	45	400	0
Cobalt	2	2	9	21.3	15.1	4,800	0
Copper	2	2	19.3	62.3	40.8	2,960	0
Iron	2	2	13,600	44,900	29,250	—	0
Lead	2	2	3.5	15.5	9.5	—	0
Magnesium	2	2	5,320	13,000	9,160	—	0
Manganese	2	2	209	486	347.5	400	1
Nickel	2	2	20.4	53.5	36.9	1,600	0
Potassium	2	2	284	1,630	957	—	0
Sodium	2	2	235	403	319	—	0
Vanadium	2	2	62.6	84.7	73.6	560	0
Zinc	2	2	30.6	103	66.8	22,400	0
Volatile Organics							
2-Butanone	2	2	0.021	0.054	0.0375	48,000	0
Acetone	2	2	0.058	0.15	0.104	8,000	0
Methylene chloride	2	2	0.001	0.002	0.0015	133	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 8
Site C-West—Chemicals Detected in the Kitsap Formation Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	1	1	16,700	16,700	16,700	—	32,400	0
Arsenic	1	1	1.2	1.2	1.2	20	7.24	0
Barium	1	1	21.1	21.1	21.1	5,600	178.8	0
Calcium	1	1	10,300	10,300	10,300	—	12,217	0
Chromium	1	1	38.5	38.5	38.5	400	72.6	0
Cobalt	1	1	17.1	17.1	17.1	4,800	28.2	0
Copper	1	1	34.9	34.9	34.9	2,960	65.2	0
Iron	1	1	28,800	28,800	28,800	—	47,007	0
Lead	1	1	3.1	3.1	3.1	—	9.01	0
Magnesium	1	1	9,640	9,640	9,640	—	20,600	0
Manganese	1	1	394	394	394	400	837	0
Mercury	1	1	0.19	0.19	0.19	24		0
Nickel	1	1	39.7	39.7	39.7	1,600	96.9	0
Sodium	1	1	175	175	175	—	957.7	0
Vanadium	1	1	67.5	67.5	67.5	560	108.5	0
Zinc	1	1	52.7	52.7	52.7	22,400	114.9	0
Volatile Organics								
2-Butanone	1	1	0.002	0.002	0.002	48,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 9
Site C-West—Chemicals Detected in Surface Water

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	No. Exceeding Potential ARAR
Metals							
Aluminum	9	8	27.3	279	90.6	—	0
Calcium	9	9	3,220	9480	7,328	—	0
Copper	9	1	5.2	5.2	5.2	2,660	0
Iron	9	9	60.6	1370	438	—	0
Magnesium	9	9	3,110	6490	5,340	—	0
Manganese	9	6	7.5	46.2	25	—	0
Sodium	9	9	2,010	4370	3,883	—	0
Zinc	9	4	8.4	12.2	10.3	16,500	0
Ordnance							
1,3,5-Trinitrobenzene	17	1	0.039	0.039	0.039	—	0
2,4,6-Trinitrotoluene	10	2	0.013	0.299	0.156	—	0
2,4-Dinitrotoluene	17	1	0.082	0.082	0.082	1,360	0
2,6-Dinitrotoluene	17	1	0.085	0.085	0.085	—	0
Nitrobenzene	17	1	0.69	0.69	0.69	449	0
RDX	17	6	0.011	0.5	0.241	—	0
Semivolatile Organics							
Benzoic acid	17	1	1	1	1	—	0
Di-n-butylphthalate	17	2	1	2	1.5	2,910	0
bis(2-ethylhexyl) phthalate	17	6	1	3	1.5	3.56	0
Volatile Organics							
Benzene	17	1	1	1	1	43	0
Vinyl chloride	17	1	12	12	12	2.92	1

Notes:
µg/L - microgram per liter
— - not applicable

Table 10
Site C-West—Chemicals Detected in Surface Sediment

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)
Metals					
Aluminum	17	17	8,290	21,300	12,701
Arsenic	17	17	1.3	11.7	3.47
Barium	17	17	25.9	289	78
Beryllium	17	7	0.39	0.87	0.544
Calcium	17	17	2,370	13,700	5,147
Chromium	17	17	18.5	56.4	30.2
Cobalt	17	17	5.4	68.9	14.3
Copper	17	17	7.4	43.7	19.4
Iron	17	17	10,000	46,600	20,688
Lead	17	17	1.7	20.2	7.15
Magnesium	17	17	3,110	9,970	5,686
Manganese	17	17	108	19,600	1,459
Nickel	17	17	25.8	78.1	44.6
Potassium	17	16	243	1,810	596
Sodium	17	17	104	437	213
Vanadium	17	17	30.9	84	47.4
Zinc	17	17	22.5	335	68.6
Ordnance					
RDX	17	3	0.608	2.594	1.78
Picric acid	9	1	0.01764	0.01764	0.0176
Pesticides/Aroclors					
Endosulfan sulfate	16	1	0.015	0.015	0.015
Semivolatile Organics					
4-Methylphenol	17	1	0.51	0.51	0.51
Acenaphthene	17	2	0.28	1.4	0.84
Acenaphthylene	17	1	0.23	0.23	0.23
Anthracene	17	2	0.41	2	1.205
Benzo(a)anthracene	17	2	1.1	5.7	3.4
Benzo(a)pyrene	17	2	1.2	6.4	3.8
Benzo(b)fluoranthene	17	3	0.26	9.5	3.85
Benzo(g,h,i)perylene	17	2	0.33	0.92	0.625
Benzo(k)fluoranthene	17	3	0.43	3.9	1.62
Benzoic acid	17	4	0.096	0.58	0.251
Chrysene	17	2	1.5	7.2	4.35
Dibenz(a,h)anthracene	17	2	0.16	0.65	0.40
Dibenzofuran	17	2	0.18	0.97	0.575
Fluoranthene	17	4	0.65	14	4.73
Fluorene	17	2	0.43	2.5	1.46
Indeno(1,2,3-cd)pyrene	17	2	0.57	2.5	1.53

Table 10 (Continued)
Site C-West—Chemicals Detected in Surface Sediment

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)
Phenanthrene	17	4	0.67	13	4.36
Pyrene	17	4	0.7	14	4.66
bis(2-ethylhexyl) phthalate	17	5	0.16	0.86	0.336
Volatile Organics					
2-Butanone	17	2	0.004	0.037	0.0205
Acetone	17	2	0.014	0.055	0.0345
Carbon disulfide	17	2	0.075	0.11	0.0925
Methylene chloride	17	1	0.027	0.027	0.027

Note: mg/kg - microgram per kilogram

Table 11
Site C-West—Chemicals Detected in the Intermediate Groundwater Zone

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	Background Value (µg/L)	No. Exceeding
Metals								
Aluminum	11	1	28.7	28.7	28.7		148	0
Arsenic	11	2	5	7.2	6.1	.05	3	2
Barium	11	6	16.3	33.1	25.7	1,000	21	0
Calcium	11	11	9,730	35,800	22,130		17,200	0
Copper	11	2	4	4	4	1,300	0	0
Iron	11	8	45	4,840	2,318		162	0
Magnesium	11	11	3,650	15,200	8,445		12,600	0
Manganese	11	11	35.1	414	214	80	176	6
Potassium	11	9	3,290	7,290	5,160		4,940	0
Sodium	11	11	6,570	19,700	13,428		12,700	0
Vanadium	11	4	6.9	19.4	13.7	112	—	0
Ordnance								
Nitrobenzene	11	2	.06	.53	.298	8	*	0
Picric acid	11	3	.5	1.02	.743		*	0
Di-n-octylphthalate	11	2	1	9	5	320	*	0
Pesticides/Arochlors								
Phenol	11	1	4	4	4	9,600	*	0
bis(2-Ethylhexyl)phthalate	11	1	6	6	6	6	*	0
Semivolatile Organics								
Acetone	11	2	11	11	11	800	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
µg/L - microgram per liter
— - not applicable
* - background established as 0

Table 12
Site C-West—Chemicals Detected in Shallow Aquifer Groundwater

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	Background	No. Exceeding Potential ARAR and Background
Metals (Dissolved)								
Aluminum	7	3	26.3	230	112	—	148	0
Arsenic	7	7	2.3	7.5	3.94	.05	3	3
Barium	7	7	16.8	28.4	22.7	1,000	21	0
Calcium	7	7	15,600	26,600	20,071	—	17,200	0
Copper	7	1	7.2	7.2	7.2	592	—	0
Iron	7	2	86.6	153	119	—	162	0
Magnesium	7	7	4,240	17,100	12,660	—	32,500	0
Manganese	7	7	90.7	367	169	80	176	2
Nickel	7	1	20.9	20.9	20.9	100	—	0
Potassium	7	4	2,020	11,200	5,510	—	4,940	0
Sodium	7	6	6,510	19,600	11,656	—	12,700	0
Vanadium	7	2	13.5	14.2	13.8	112	—	0
Zinc	7	3	8.3	54.3	24	4,800	15	0
Volatile Organic								
1,1,1-Trichloroethane	7	1	2	2	2	200	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
µg/L - microgram per liter
— - not applicable
* - background established as 0

Ethylbenzene, toluene, and xylene were usually detected together. These compounds are commonly found in fuel hydrocarbons; proximity of sampling locations to the paved roadway and parking lot make motor vehicles a likely source for these compounds. All detections were below regulatory criteria; therefore, none of these compounds were considered in the risk assessment as a chemical of potential concern.

Bis(2-ethylhexyl) phthalate, benzoic acid, and pyrene were detected in isolated samples below screening criteria. These samples were taken adjacent to an asphalt-paved road and parking area, which may be the source of these compounds.

One ordnance compound, 2,6-dinitrotoluene (2,6-DNT), was detected at a concentration below the screening criteria. This detection is within the suspected fill area on Site C-West.

Pesticides and PCBs were not detected in Site C-West surface soils.

7.1.2 Subsurface Soils

During July and August 1991, 21 soil borings were drilled at Site C-West; soil boring depths ranged from 31.20 ft mean sea level (msl) in CW-MW30 to 97.19 ft msl in CW-MW27. All samples were drilled by using hollow-stem auger methods. Samples were collected from the surface to total boring depth by using a 2-inch-diameter split spoon for visual classification. Fifty-four of the samples collected were classified as representative and sent to an off-site laboratory for chemical analyses. Tables 3 through 8 show data for subsurface soils.

In an attempt to locate the contact between the overlying fill and the Vashon Till, three of the 21 borings—SB-5, SB-9, and SB-10—were drilled deeper than originally planned, as specified in project work plans. Two of these—SB-9 and SB-10—reached auger refusal at 21.5 and 23.5 feet, respectively. The third, SB-5, encountered the contact between the fill and the Vashon Till at 30 feet. Samples in these deeper borings were collected from 0 to 10 feet. Below 10 feet, samples were collected for chemical analysis at 10-foot intervals. Three additional borings were drilled near SB-10 to determine the limits of fill on the south side of Site C-West. Only samples collected between 0 and 3 feet below ground surface from these borings were shipped to a laboratory for ordnance analyses.

Subsurface soil samples from 17 soil borings and four monitoring wells at Site C-West were analyzed for volatile and semivolatile organics, pesticides, metals, and ordnance compounds. Subsurface soil is defined as soil at a depth greater than 6 inches.

The following are the findings for subsurface soils sampling.

Metals. Beryllium and manganese were commonly detected routinely at concentrations above screening criteria throughout all geologic formations.

Beryllium concentrations exceed screening criteria in the fill area. No appropriate background concentrations are available for the fill.

Organic Compounds. VOCs detected were acetone, 2-butanone, toluene, ethylbenzene, xylenes, and methylene chloride. All VOC detections were below screening criteria.

Semivolatile organic compounds (SVOCs) detected at Site C-West were bis(2-ethylhexyl) phthalate, pyrene, 4-methylphenol, benzoic acid, di-n-octylphthalate, and di-n-butylphthalate.

Ordnance compounds detected at Site C-West include 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, picric acid, picramic acid, nitrobenzene, Otto fuel, and Royal Demolition Explosive (RDX). All ordnance detections were below screening concentrations.

No pesticides or PCBs were detected in subsurface soils from C-West.

7.1.3 Surface Water and Sediment (Site C-West and Site C-East)

Sample locations C-SW/SD01 through C-SW/SD06 and C-SW/SD12 were sampled once during base flow (April 16 through April 23, 1991) and once after a storm event (August 29 through August 30, 1991). C-SW/SD07 was sampled only once because of lack of surface water flow conditions. Sample locations for surface water and sediment for Site C are shown in Figure 8.

Stormwater at Site C-East drains both to the wetland and then west and south of Hunter's Marsh and also drains directly to the stream leading to Hunter's Marsh. Stormwater at Site C-West drains to storm sewers within the paved area.

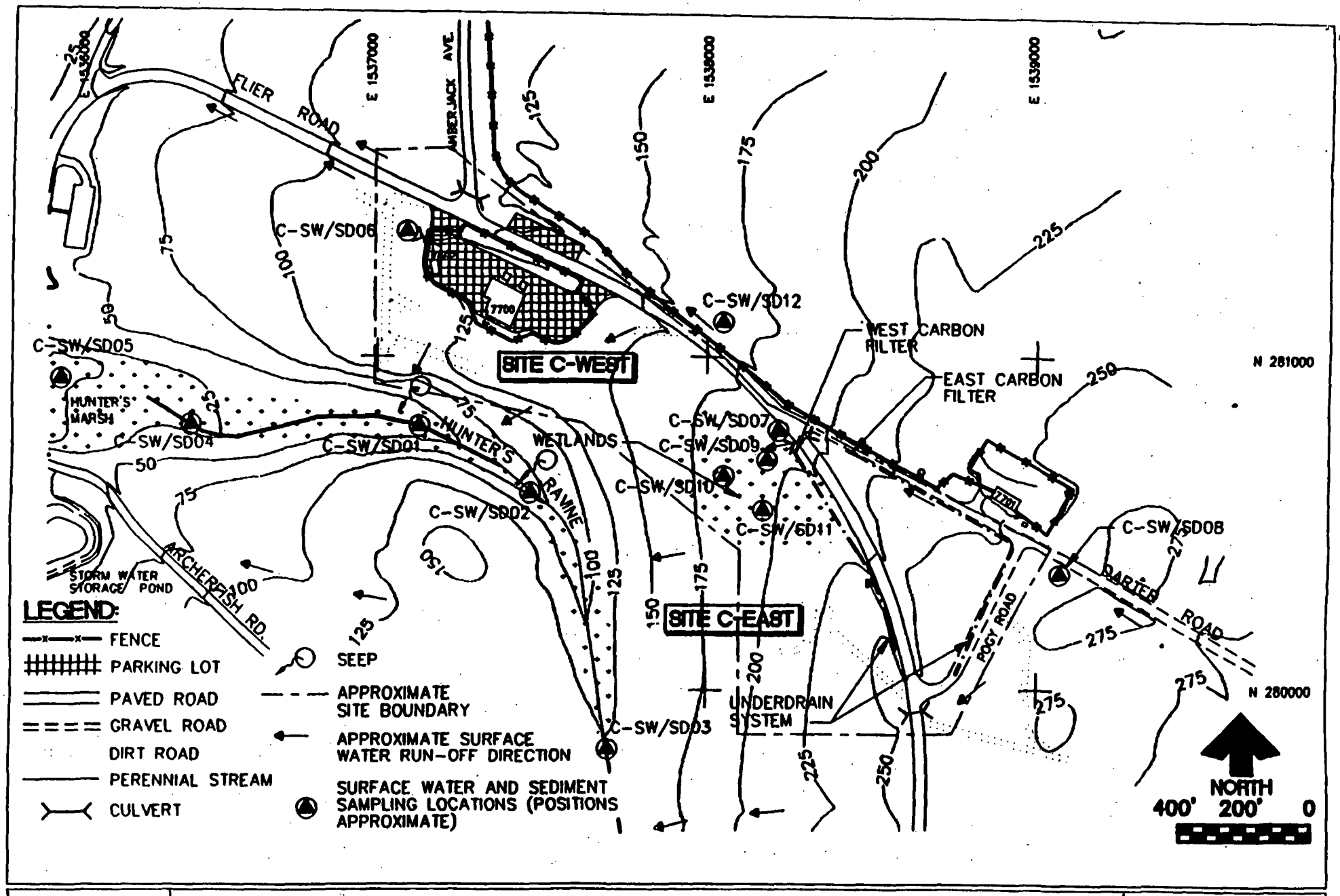


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Figure 8
Site C
Surface Water and Sediment Sampling Locations

CTO 0039
Operable Unit 4
SUBASE, Bangor
Washington
RECORD OF DECISION

Site C-East baseflow sampling was performed at C-SD08 in October 1991; storm event sampling was performed at locations C-SD08 through C-SD11 in November 1991 and again at C-SD08 in January 1992. Site C samples are compared to upgradient sample stations (C-SD03 and C-SD08). No screening criteria have been established for freshwater sediments. Ecology has presented sediment criteria from various North American sources (Ecology 1991). Data are intended as guideline concentrations.

The following are the findings for surface water and sediment sampling by class of analytes.

Metals. Metals results are presented below.

Surface Water. No metals were detected at concentrations that exceed screening criteria.

Sediment. Samples C-SD03 and C-SD08 are considered upgradient upstream sampling locations. C-SD12 is an off-site sampling location, hydraulically unrelated to Site C.

Arsenic, barium, chromium, manganese, nickel, and zinc exceeded upstream concentrations at C-SD04, C-SD05, and C-SD06 during round 1 sampling. Chromium and zinc exceeded upstream concentrations at C-SD05 during round 2 sampling. Metal concentrations remained above screening criteria during round 2 sampling at C-SD06. Barium, nickel, and zinc were at concentrations above screening criteria during round 2 sampling at C-SD09. Barium, chromium, copper, selenium, and zinc were also detected above upstream concentrations at C-SD10 during round 2 sampling.

Sampling locations C-SD01, C-SD02, C-SD03, and C-SD04 are in Hunter's Ravine. Sampling location C-SD05 is in Hunter's Marsh, which is currently being investigated under OU 7. The source of metal concentrations in sediment from Hunter's Ravine and Hunter's Marsh is unknown; these sediments receive surface water runoff from a variety of sources, including Site C.

Organic Compounds. Organic compound results are presented below.

Surface Water. VOCs detected in surface water include benzene, tetrachloroethene (PCE), toluene, and vinyl chloride. Vinyl chloride and tetrachloroethene exceeded screening criteria one time each. Vinyl chloride was detected in surface waters at C-SW06 (Figure 8) near the asphalt-paved parking area of Building 7700. Tetrachloroethene was detected at C-SW08, which is upgradient of Site C-East.

Ordnance compounds detected in surface water runoff for Site C include 2,4-DNT, 2,6-DNT, nitrobenzene, 1,3,5-trinitrobenzene, 2,4,6-trinitrotoluene, RDX, and Otto fuel. These ordnance compounds were detected at concentrations below screening criteria. Otto fuel was detected once off site at C-SW09 in Hunter's Marsh.

No SVOCs, pesticides, or PCBs were detected in surface water at Site C.

Sediment. VOCs detected in sediments include acetone, 2-butanone, benzene, xylenes, carbon disulfide, and methylene chloride. Acetone, benzene, and methylene chloride were detected at upstream sampling location C-SD08. Acetone, 2-butanone, and carbon disulfide were detected in Hunter's Marsh, but were not detected at upstream sampling locations in Hunter's Ravine. Methylene chloride was also detected at sampling locations C-SD10 and C-SD11 in the wetlands, downslope of Site C-East. Methylene chloride was widely detected in soils at Site C-East. These VOCs are suspected to have migrated from the source at Pit A or B through the perched aquifer, as the perched aquifer discharges into the wetland. With the exception of acetone, all VOCs were detected during the storm event sampling.

The source of acetone and 2-butanone in sediments of Hunter's Marsh may be from surface water runoff or from groundwater discharged into Hunter's Ravine. None of the VOCs detected are at levels of potential concern.

Several SVOCs were detected at low frequency in sediment samples at Site C (Tables 10 and 21).

RDX and picric acid were the only ordnance compounds detected in sediments. They were found at sampling locations C-SD12 and C-SD07 (Figure 8), respectively, during baseflow conditions. These ordnance compounds were below screening criteria and are not considered compounds of potential concern at Site C.

7.1.4 Groundwater

Groundwater monitoring wells at Site C-West (Figure 6) were installed in four clusters of two wells each. Monitoring wells CW-MW26 and CW-MW27 were upgradient of Site C-West and downgradient of Site C-East. Monitoring wells CW-MW28 and CW-MW29 were installed downgradient of Site C-West in the southwest portion of the site. Monitoring wells CW-MW30 and CW-MW31 were also installed downgradient of Site C-West, approximately 200 feet west of CW-MW29. These clusters were located to

provide data on the nature and extent of chemical compounds present in the subsurface soil and groundwater and to establish groundwater flow directions and gradients. The cluster containing CW-MW32 and CW-MW33 was installed north of Flier Road to provide water quality data north of Site C-West and as a third point for determining groundwater flow direction.

One of the wells in each pair was completed in the upper shallow aquifer. The second well was completed in the lower shallow aquifer in the Kitsap Formation.

Monitoring well installation was conducted in two phases. Monitoring wells CW-MW26 and CW-MW27 were installed between April and July 1991. Monitoring wells CW-MW28 through CW-MW33 were installed in November 1991. All monitoring wells have 10-foot screened sections except well CW-MW26, which has a 5-foot screen because the aquifer was determined to be less than 10 feet thick at that location.

Existing monitoring well C-MW25 was used to provide additional data at Site C-West. Well C-MW25 was screened in the Vashon Till; it is downgradient of well cluster C-MW30 and C-MW31.

Monitoring well C-MW25 is screened in a permeable zone in the Vashon Till. It is discussed below as a shallow aquifer well. Monitoring wells CW-MW27, CW-MW29, CW-MW31, and CW-MW33 are screened in the shallow aquifer. Monitoring wells CW-MW26, CW-MW28, CW-MW30, and CW-MW32 are screened in the intermediate groundwater zones of the Kitsap Formation. A perched aquifer is not present at Site C-West.

The following findings are presented for groundwater sampling by level and class of analytes.

Metals. Metals results are presented below.

Shallow Aquifer. The concentrations of dissolved metals in the shallow aquifer of Site C-West were compared to screening criteria. Only arsenic and manganese exceeeded these screening criteria.

Turbidity levels were greater than 200 nephelometric turbidity units (NTU) in most samples. The high turbidity in these samples is likely the result of the fine-grained silt present in the glacially deposited sediments. Particulates contained in these samples are

the likely source of the elevated total metal concentrations in the shallow aquifer wells. The dissolved metals analysis supports this hypothesis because only background groundwater metals were detected in filtered samples.

Intermediate Groundwater Zones (IGZ). The concentrations of dissolved metals detected in the groundwater of the IGZ of Site C-West were compared to screening criteria values. Arsenic and manganese were the only metals that exceeded these criteria.

Turbidity levels were greater than 200 NTU in most samples. Only common metals, such as calcium and magnesium, were detected. Given observed dissolved metals concentrations, none of the metals detected in the shallow aquifer or the IGZ of Site C-West are considered compounds of concern.

Organic Compounds. Organic compound results are presented below.

No organic compounds were detected above screening criteria in the shallow or intermediate groundwater zones.

No pesticides or PCBs were detected in groundwater at Site C-West.

Two ordnance compounds, nitrobenzene and picric acid, were detected at a low frequency at concentrations below screening criteria.

7.2 SITE C-EAST

Site C-East sample locations and results are presented in the following section, along with the findings from the RI/FS. Tables 13 through 23 present the chemicals detected at the site for each medium, compared to risk-based screening levels calculated by using the assumptions and procedures. These tables show exceedances of potential ARAR and background. If no ARAR exists for a chemical, then no exceedances were reported. If no background exists for a chemical, then the exceedance is for the ARAR only. Surface water and sediments for Sites C-West and C-East were discussed in Section 7.1. No additional discussion will be included in Section 7.2.

Table 13
Site C-East—Chemicals Detected in Surface Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	36	36	6,560	17,200	12,430	—	19,546	0
Arsenic	36	34	1.1	4.6	1.93	20	3.69	0
Barium	36	36	40.6	92	58.9	5,600	134	0
Beryllium	3	1	0.23	0.23	0.23	0.233	0.49	0
Cadmium	36	34	0.21	1.1	0.582	40	0.55	0
Calcium	36	36	1,080	5,990	2,480	—	3,273	0
Chromium	36	36	13.1	27.2	21.1	400	34	0
Cobalt	36	36	2.8	11.6	7.05	4,800	7.75	0
Copper	36	36	9.8	55.8	21.9	2,960	16	0
Iron	36	36	4,340	17,400	12,238	—	16,958	0
Lead	36	36	2.8	88.8	9.75	—	31.8	0
Magnesium	36	36	883	5,920	3,727	—	4,033	0
Manganese	36	36	51.8	973	372	400	1,002	0
Mercury	36	6	0.13	1	0.356	24	0.1	0
Nickel	36	36	9.7	93.2	41.1	1,600	63.3	0
Potassium	36	36	58.8	483	288	—	338	0
Silver	36	25	0.41	5.4	1.0	240	0.97	0
Sodium	36	35	77.4	620	242	—	476	0
Vanadium	36	36	14.3	38.4	28.6	560	35.7	0
Zinc	36	36	9.5	45.5	25.2	22,400	38.4	0
Ordnance								
Otto Fuel	36	2	0.058	0.11	0.084	—	*	0
Semivolatile Organics								
4-Methylphenol	33	1	0.051	0.051	0.051	4,000	*	0
Benzo(b)fluoranthene	33	1	0.13	0.13	0.13	0.137	*	0
Benzoic acid	33	10	0.015	0.072	0.0359	320,000	*	0
Chrysene	33	1	0.11	0.11	0.11	0.137	*	0
Di-n-butylphthalate	33	4	0.045	0.056	0.0495	8,000	*	0
Fluoranthene	33	1	0.15	0.15	0.15	3,200	*	0
Phenanthrene	33	1	0.1	0.1	0.1	—	*	0
Pyrene	33	1	0.13	0.13	0.13	2,400	*	0
bis(2-Ethylhexyl)phthalate	36	12	0.048	1.6	0.347	71.4	*	0
Volatile Organics								
1,1,1-Trichloroethane	36	6	0.001	0.003	0.002	7,200	*	0
2-Butanone	36	3	0.018	0.029	0.0243	48,000	*	0
Acetone	36	13	0.006	0.35	0.0676	8,000	*	0
Benzene	36	1	0.002	0.002	0.002	34.5	*	0

Table 13 (Continued)
Site C-East—Chemicals Detected in Surface Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Chloroform	36	10	0.0007	0.004	0.00234	164	*	0
Ethylbenzene	33	5	0.001	0.009	0.0052	8,000	*	0
Methylene chloride	36	29	0.004	0.14	0.040	133	*	0
Tetrachloroethene	36	34	0.006	0.54	0.135	19.6	*	0
Toluene	36	16	0.0009	0.016	0.00624	16,000	*	0
Xylenes	36	13	0.0009	0.015	0.00444	165,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
— - Not applicable
* - Background established as zero
mg/kg - milligram per kilogram

Table 14
Site C-East—Chemicals Detected in the Structural Fill Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	25	25	8,930	19,200	12,721	—	0
Antimony	25	3	6	8.7	7.26	32	0
Arsenic	25	4	1.5	2.1	1.67	20	0
Barium	25	25	32.6	83	51.6	5,600	0
Beryllium	25	13	0.22	0.29	0.256	0.233	12
Cadmium	25	3	0.25	0.68	0.413	40	0
Calcium	25	25	1,460	5,590	2,855	—	0
Chromium	25	25	19.7	42.4	25.2	400	0
Cobalt	25	25	5.3	17.7	7.72	4,800	0
Copper	25	25	7.8	26.5	14.1	2,960	0
Iron	25	25	10,900	19,000	13,140	—	0
Lead	25	24	1.4	7.1	2.66	—	0
Magnesium	25	25	3,350	6,890	5,030	—	0
Manganese	25	25	143	564	257	400	2
Mercury	25	6	0.11	0.2	0.135	24	0
Nickel	25	24	36.8	187	56.1	1,600	0
Potassium	25	25	240	556	399	—	0
Silver	25	2	0.49	1.3	0.895	240	0
Sodium	25	22	66.3	761	230	—	0
Vanadium	25	25	24.2	47	30.9	560	0
Zinc	25	25	20	34.2	24	22,400	0
Semivolatile Organics							
Di-n-octylphthalate	25	2	0.6	0.76	0.68	1,600	0
bis(2-Ethylhexyl)phthalate	25	10	0.071	0.76	0.312	71.4	0
Volatile Organics							
Acetone	25	2	0.01	0.066	0.038	8,000	0
Carbon disulfide	25	1	0.005	0.005	0.005	800	0
Chlorobenzene	25	1	0.004	0.004	0.004	1,600	0
Methylene chloride	25	2	0.012	0.015	0.0135	133	0
Tetrachloroethene	25	5	0.002	0.026	0.0108	19.6	0
Trichloroethene	25	1	0.002	0.002	0.002	90.9	0

Notes:
ARAR = applicable or relevant and appropriate requirement
mg/kg = milligram per kilogram
— = not applicable
* = background established as zero

Table 15
Site C-East—Chemicals Detected in the Vashon Recessional Outwash Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	24	24	6,110	22,400	10,915	—	0
Antimony	24	4	7.3	19.7	11.7	32	0
Arsenic	24	12	1.2	6.3	2.15	20	0
Barium	24	24	20.1	140	43.1	5,600	0
Beryllium	24	7	0.22	0.4	0.27	0.233	4
Cadmium	24	3	0.32	0.73	0.526	40	0
Calcium	24	24	1,480	7,910	3,878	—	0
Chromium	24	24	13.8	85.1	27.4	400	0
Cobalt	24	24	3.8	16.4	7.48	4,800	0
Copper	24	24	8.1	30.1	16.6	2,960	0
Iron	24	24	8,770	28,400	13,572	—	0
Lead	24	23	1.3	4.2	2.0	—	0
Magnesium	24	24	3,450	9,010	4,835	—	0
Manganese	24	24	121	432	234	400	1
Mercury	24	1	0.12	0.12	0.12	24	0
Nickel	24	24	26.3	77.4	42.9	1,600	0
Potassium	24	24	198	1,400	410	—	0
Silver	24	1	0.46	0.46	0.46	240	0
Sodium	24	21	110	645	331	—	0
Vanadium	24	24	17.8	79.7	33.6	560	0
Zinc	24	24	15.7	56.4	23.9	22,400	0
Ordnance							
Otto Fuel	24	1	0.082	0.082	0.082	—	0
Semivolatile Organics							
Benzo(a)pyrene	23	1	0.75	0.75	0.75	0.137	1
Di-n-octylphthalate	23	6	0.081	0.72	0.323	1,600	0
bis(2-Ethylhexyl)phthalate	23	3	0.067	0.5	0.255	71.4	0
Volatile Organics							
Acetone	24	12	0.005	0.033	0.0128	8,000	0
Methylene chloride	24	6	0.002	0.016	0.00533	133	0
Tetrachloroethene	24	3	0.001	0.004	0.00266	19.6	0

Notes:
ARAR = applicable or relevant and appropriate requirement
mg/kg = milligram per kilogram
— = *not applicable*
* = background established as zero

Table 16
Site C-East—Chemicals Detected in the Vashon Till Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	24	24	5,790	35,200	13,290	—	12,258	0
Antimony	24	21	6.9	57.9	16.6	32	—	3
Arsenic	24	18	1.1	6.2	2.56	20	1.65	0
Barium	24	24	28	247	76.6	5,600	51.8	0
Beryllium	24	8	0.22	0.41	0.311	0.233	0.68	0
Cadmium	24	11	0.23	1.1	0.514	40	—	0
Calcium	24	24	2,480	11,900	6,654	—	4,282	0
Chromium	24	24	17.6	80.7	39.8	400	26.6	0
Cobalt	24	24	5.6	28	11.1	4,800	10.6	0
Copper	24	24	12	107	28.5	2,960	21.3	0
Iron	24	24	10,300	51,800	19,758	—	15,816	0
Lead	24	24	1.2	13.6	3.92	—	1.97	0
Magnesium	24	24	4,480	22,600	8,166	—	6,415	0
Manganese	24	24	140	1,020	336	400	311	5
Mercury	24	2	0.1	0.1	0.1	24	0.08	0
Nickel	24	24	26.9	106	51.9	1,600	76.9	0
Potassium	24	24	295	4,730	984	—	490	0
Selenium	24	3	0.43	0.61	0.49	400	—	0
Silver	24	4	0.43	2	0.942	240	—	0
Sodium	24	24	161	1,210	628	—	461	0
Thallium	24	2	1.1	1.1	1.1	5.6	—	0
Vanadium	24	24	19.5	103	49.1	560	36.9	0
Zinc	24	24	17.9	112	40.8	22,400	31.5	0
Semivolatile Organics								
Benzo(a)pyrene	24	2	0.32	1	0.66	0.137	*	2
Di-n-octylphthalate	24	1	0.85	0.85	0.85	1,600	*	0
bis(2-Ethylhexyl)phthalate	24	4	0.073	1.1	0.34	71.4	*	0
Volatile Organics								
2-Butanone	24	2	0.29	0.8	0.545	48,000	*	0
Acetone	24	16	0.008	1.1	0.0865	8,000	*	0
Benzene	24	1	0.061	0.061	0.061	34.5	*	0
Methylene chloride	24	3	0.064	0.52	0.314	133	*	0
Tetrachloroethene	24	2	0.001	0.002	0.0015	19.6	*	0
Toluene	24	1	0.015	0.015	0.015	16,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 17
Site C-East—Chemicals Detected in the Vashon Advance Outwash

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	29	29	8,870	19,900	13,842	—	14,094	0
Antimony	29	23	4.5	20	10.2	32	—	0
Arsenic	29	29	1.5	6.2	3.97	20	5.1	0
Barium	29	29	46	128	83.9	5600	76.6	0
Beryllium	29	17	0.25	0.44	0.328	0.233	0.58	0
Cadmium	29	11	0.25	0.62	0.388	40	—	0
Calcium	29	29	3,640	10,600	7,819	—	8,458	0
Chromium	29	29	27.7	66	45.5	400	41.8	0
Cobalt	29	29	6.4	17.9	13.1	4,800	14.7	0
Copper	29	29	16.2	41.2	28.5	2,960	29.4	0
Iron	29	29	12,500	29,900	21,375	—	22,928	0
Lead	29	29	1.5	6.9	4.2	—	3.94	0
Magnesium	29	29	4,530	17,600	11,731	—	13,460	0
Manganese	29	29	154	553	366.9	400	386	12
Nickel	29	29	31.9	120	75.0	1600	91.8	0
Potassium	29	29	345	2,120	1,236	—	1,236	0
Selenium	29	1	0.67	0.67	0.67	400	—	0
Silver	29	8	0.49	1.5	0.953	240	2.56	0
Sodium	29	29	223	1040	588	—	450.6	0
Vanadium	29	29	29.3	65.8	48.5	560	55.7	0
Zinc	29	29	22.6	65.5	44.8	22,400	46	0
Semivolatile Organics								
Benzo(a)pyrene	26	4	0.26	1.3	0.587	0.137	*	4
bis(2-Ethylhexyl)phthalate	26	2	0.081	0.11	0.0955	71.4	*	0
Volatile Organics								
1,1,1-Trichloroethane	29	1	0.019	0.019	0.019	7,200	*	0
1,1,2,2-Tetrachloroethane	29	1	0.006	0.006	0.006	5	*	0
2-Butanone	29	2	0.03	0.07	0.05	48,000	*	0
Acetone	29	18	0.003	0.1	0.0329	8,000	*	0
Benzene	29	1	0.003	0.003	0.003	34.5	*	0
Carbon disulfide	29	1	0.002	0.002	0.002	800	*	0
Chloroform	29	8	0.001	0.002	0.00187	164	*	0
Methylene chloride	29	21	0.003	0.078	0.0203	133	*	0

Table 17 (Continued)
Site C-East—Chemicals Detected in the Vashon Advance Outwash

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Tetrachloroethene	29	7	0.005	0.13	0.038	19.6	*	0
Toluene	29	4	0.0008	0.008	0.0032	16,000	*	0
Xylenes	29	1	0.002	0.002	0.002	165,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 18
Site C-East—Chemicals Detected in the Intermediate Groundwater Zone Soil

Chemical	# of Samples	# of Detects	Min Detect (mg/kg)	Max Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	No. Exceeding Potential ARAR
Metals							
Aluminum	1	1	13,400	13,400	13,400	—	0
Antimony	1	1	10.8	10.8	10.8	32	0
Arsenic	1	1	4.4	4.4	4.4	20	0
Barium	1	1	82.6	82.6	82.6	5,600	0
Beryllium	1	1	0.24	0.24	0.24	0.233	1
Cadmium	1	1	0.32	0.32	0.32	40	0
Calcium	1	1	4,410	4,410	4,410	—	0
Chromium	1	1	39.7	39.7	39.7	400	0
Cobalt	1	1	8.7	8.7	8.7	4,800	0
Copper	1	1	18.8	18.8	18.8	2,960	0
Iron	1	1	14,500	14,500	14,500	—	0
Lead	1	1	5	5	5	—	0
Magnesium	1	1	5,030	5,030	5,030	—	0
Manganese	1	1	171	171	171	400	0
Nickel	1	1	42.6	42.6	42.6	1,600	0
Potassium	1	1	466	466	466	—	0
Silver	1	1	0.48	0.48	0.48	240	0
Sodium	1	1	510	510	510	—	0
Vanadium	1	1	47.6	47.6	47.6	560	0
Zinc	1	1	33.9	33.9	33.9	22,400	0
Semivolatile Organics							
Benzo(a)pyrene	1	1	0.49	0.49	0.49	0.137	1
Volatile Organics							
2-Butanone	1	1	0.045	0.045	0.045	48,000	0
Acetone	1	1	0.13	0.13	0.13	8,000	0
Chloroform	1	1	0.002	0.002	0.002	164	0
Methylene chloride	1	1	0.018	0.018	0.018	133	0
Xylenes	1	1	0.002	0.002	0.002	165,000	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 19
Site C-East—Chemicals Detected in the Kitsap Formation Soil

Chemical	# of Samples	# of Detects	Min. Detect (mg/kg)	Max. Detect (mg/kg)	Mean Detect (mg/kg)	Potential ARAR (mg/kg)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	2	2	37,800	38,700	38,250	—	32,400	0
Antimony	2	2	23.9	26.4	25.1	32	—	0
Arsenic	2	2	5	5.4	5.2	20	7.24	0
Barium	2	2	210	235	222	5,600	178.8	0
Beryllium	2	1	0.27	0.27	0.27	0.233	1.52	0
Cadmium	2	2	0.7	0.72	0.71	40	—	0
Calcium	2	2	13,000	16,200	14,600	—	12,217	0
Chromium	2	2	75.8	80.1	77.9	400	72.6	0
Cobalt	2	2	25.1	27.8	26.4	4,800	28.2	0
Copper	2	2	65.9	72.9	69.4	2,960	65.2	0
Iron	2	2	47,500	52,000	49,750	—	47,007	0
Lead	2	2	5.2	12.4	8.8	—	9.01	0
Magnesium	2	2	22,700	24,900	23,800	—	20,600	0
Manganese	2	2	1,020	1,120	1070	400	837	2
Mercury	2	1	0.13	0.13	0.13	24	—	0
Nickel	2	2	85.8	94.6	90.2	1,600	96.9	0
Potassium	2	2	4,980	5,140	5,060	—	4,518	0
Selenium	2	2	0.54	0.79	0.665	400	—	0
Silver	2	2	0.76	0.83	0.795	240	3.36	0
Sodium	2	2	970	1,120	1,045	—	957.7	0
Thallium	2	1	1.3	1.3	1.3	5.6	—	0
Vanadium	2	2	96	101	98.5	560	108.5	0
Zinc	2	2	114	135	124	22,400	114.9	0
Semivolatile Organics								
bis(2-Ethylhexyl)phthalate	2	1	0.039	0.039	0.039	71.4	*	0
Volatile Organics								
Acetone	2	2	0.012	0.015	0.0135	8,000	*	0
Carbon disulfide	2	1	0.001	0.001	0.001	800	*	0
Chloroform	2	2	0.001	0.002	0.0015	164	*	0
Methylene chloride	2	2	0.014	0.05	0.032	133	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
mg/kg - milligram per kilogram
— - not applicable
* - background established as zero

Table 20
Site C-East—Chemicals Detected in Surface Water

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	No. Exceeding Potential ARAR
Metals							
Aluminum	5	5	126	451	287.4	—	0
Barium	5	4	116	121	118.75	—	0
Cadmium	5	1	3.2	3.2	3.2	20.3	0
Calcium	5	5	1,380	7,250	4,506	—	0
Chromium	5	1	2	2	2	162,000	0
Copper	5	1	6.8	6.8	6.8	2,660	0
Iron	5	5	112	202	160.6	—	0
Lead	5	2	1.8	2.3	2.05	—	0
Magnesium	5	5	483	2,980	1,820.2	—	0
Manganese	5	4	3.8	43.1	22.25	—	0
Potassium	5	4	405	1,330	1,063.75	—	0
Sodium	5	5	959	5,050	3,393.8	—	0
Zinc	5	2	2.9	10.3	6.6	16,500	0
Ordnance							
2,6-Dinitrotoluene	5	1	0.012	0.012	0.012	—	0
Otto Fuel	5	1	0.057	0.057	0.057	—	0
Volatile Organics							
Benzene	5	1	10	10	10	43	0
Tetrachloroethene	5	1	6	6	6	4.15	1
Toluene	5	1	2	2	2	48,500	0

Notes:
ARAR - applicable or relevant and appropriate requirement
µg/L - microgram per liter
— - not applicable

Table 21
Site C-East—Chemicals Detected in Surface Sediment

Chemical	# of Samples	# of Detects	Min Detect (µg/kg)	Max Detect (µg/kg)	Mean Detect (µg/kg)
Metals					
Aluminum	7	7	12,900	20,200	17,228
Antimony	7	2	6.1	24.4	15.2
Arsenic	7	4	1.2	2.3	1.72
Barium	7	7	52.3	1,610	281
Beryllium	7	3	0.24	0.34	0.276
Calcium	7	7	4,540	6,410	5,717
Chromium	7	7	26	45.3	31.4
Cobalt	7	7	8.2	13.2	11.3
Copper	7	7	11.7	125	40.1
Iron	7	7	10,500	20,800	16,757
Lead	7	7	3.7	22.2	8.41
Magnesium	7	7	2,510	7,050	5,498
Manganese	7	7	141	499	343
Mercury	7	1	0.16	0.16	0.16
Nickel	7	7	35.2	52.8	42.4
Potassium	7	7	456	824	583
Selenium	7	1	1.9	1.9	1.9
Silver	7	2	1	2	1.5
Sodium	7	6	154	1,040	422
Vanadium	7	7	34.6	53	42.2
Zinc	7	7	27	151	51.9
Semivolatile Organics					
bis(2-Ethylhexyl)phthalate	6	2	0.074	0.087	0.0805
Volatile Organics					
Acetone	7	3	0.01	0.027	0.0183
Benzene	7	1	0.006	0.006	0.006
Methylene chloride	7	6	0.005	0.066	0.028
Xylenes	7	1	0.002	0.002	0.002

Note:
µg/kg - microgram per kilogram

Table 22
Site C-East—Chemicals Detected in the Perched Groundwater

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Metals (Dissolved)								
Aluminum	17	11	99	312	172	—	148	0
Antimony	17	1	19	19	19	6.4	—	1
Arsenic	17	6	5.3	35.5	14.5	0.05	3	6
Barium	17	8	10.5	70.9	32.7	1,120	21	0
Calcium	17	17	4,040	28,000	10,020	—	17200	0
Chromium	17	6	3.8	5.6	4.58	16,000	—	0
Copper	17	10	4.6	31.1	11.1	592	—	0
Iron	17	15	14.6	1,770	326	—	162	0
Lead	17	4	1.2	2.7	1.87	—	—	0
Magnesium	17	17	1,760	14,500	5,092	—	12600	0
Manganese	17	16	2	343	71.3	80	176	3
Mercury	17	1	3.6	3.6	3.6	4.8	—	0
Potassium	17	10	425	2,300	1,283	—	4940	0
Sodium	17	17	3,130	8,330	4,712	—	12700	0
Thallium	17	1	3.7	3.7	3.7	1.12	—	1
Vanadium	17	2	3.1	3.5	3.3	112	—	0
Zinc	17	12	4.5	156	27.9	4,800	15	0
Ordnance								
2,4,6-Trinitrotoluene	14	6	0.016	0.36	0.107	2.92	•	0
2,4-Dinitrotoluene	17	4	0.024	0.068	0.0457	32	•	0
2,6-Dinitrotoluene	17	4	0.01	0.028	0.018	16	•	0
Otto Fuel	10	3	0.064	1	0.391	—	•	0
RDX	17	1	0.48	0.48	0.48	0.795	•	0
Semivolatile Organics								
Butylbenzylphthalate	16	1	4	4	4	3,200	•	0
Di-n-butylphthalate	16	3	1	4	3	1,600	•	0
Di-n-octylphthalate	16	7	1	38	11.4	320	•	0
Diethylphthalate	16	2	3	3	3	12,800	•	0
Naphthalene	16	1	4	4	4	32	•	0
bis(2-ethylhexyl) phthalate	16	8	1	24	9.12	6.25	•	4

Table 22 (Continued)
Site C-East—Chemicals Detected in the Perched Groundwater

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	Background Value (mg/kg)	No. Exceeding Potential ARAR and Background
Volatile Organics								
1,1,1-Trichloroethane	17	1	2	2	2	720	•	0
Acetone	17	1	12	12	12	800	•	0
Benzene	17	1	5	5	5	1.51	•	1
Methylene chloride	17	1	3	3	3	5.83	•	0
Tetrachloroethene	17	1	2	2	2	0.858	•	1

Notes:
ARAR - applicable or relevant and appropriate requirement
µg/L - microgram per liter
— - not applicable
• - background established as 0

Table 23
Site C-East—Chemicals Detected in the Shallow Aquifer Groundwater

Chemical	# of Samples	# of Detects	Min Detect (ug/L)	Max Detect (ug/L)	Mean Detect (ug/L)	Potential ARAR (ug/L)	Background Values (ug/kg)	No. Exceeding Potential ARAR and Background
Metals								
Aluminum	24	19	67	11,900	791	—	148	0
Arsenic	24	9	2.9	11.8	5.87	0.05	3	7
Barium	24	24	14.4	185	59.2	1000	21	0
Calcium	24	24	9,690	29,200	20,382	—	17,200	0
Chromium	24	6	2.2	44.4	10.8	50	—	0
Cobalt	24	1	28.7	28.7	28.7	960	—	0
Copper	24	3	6.1	26.9	16.8	1300	—	0
Iron	24	19	21.3	28,000	1,728	—	162	0
Lead	24	8	1.2	19.3	4.5	15	—	1
Magnesium	24	24	4,560	19,000	10,817	—	12,600	0
Manganese	24	24	3	791	230	80	176	12
Mercury	24	3	0.31	1.7	1.07	2	—	0
Nickel	24	2	7.3	162	84.6	100	—	1
Potassium	24	24	1,140	3,460	2,138	—	4,940	0
Sodium	24	24	6,300	43,600	13,102	—	12,700	0
Vanadium	23	1	49.1	49.1	49.1	112	—	0
Zinc	24	15	2.2	86.7	20.3	4,800	15	0
Ordnance								
2,4,6-Trinitrotoluene	21	2	0.009	0.018	0.0135	2.92	*	0
Otto Fuel	21	3	0.11	0.4	0.243	—	*	0
RDX	21	6	0.025	0.081	0.0518	0.795	*	0
Pesticides/Arochlors								
Methoxychlor	24	1	0.92	0.92	0.92	40	*	0
Semivolatile Organics								
4-Nitrophenol	24	1	20	20	20	—	*	0
Di-n-butylphthalate	24	1	8	8	8	1,600	*	0
Di-n-octylphthalate	24	3	1	16	8.33	320	*	0
Naphthalene	24	1	2	2	2	32	*	0
Nitrobenzene	24	2	3	5	4	8	*	0
bis(2-ethylhexyl) phthalate	24	6	1	20	5.16	6	*	1
Volatile Organics								
1,1,1-Trichloroethane	25	6	3	13	8.66	200	*	0
1,1-Dichloroethene	25	3	1	2	1.33	7	*	0
Acetone	25	3	7	11	8.66	800	*	0
Benzene	25	1	2	2	2	5	*	0

Table 23 (Continued)
Site C-East—Chemicals Detected in the Shallow Aquifer Groundwater

Chemical	# of Samples	# of Detects	Min Detect (µg/L)	Max Detect (µg/L)	Mean Detect (µg/L)	Potential ARAR (µg/L)	Background Values (mg/kg)	No. Exceeding Potential ARAR and Background
Chlorobenzene	25	1	2	2	2	100	*	0
Chloroform	25	1	3	3	3	100	*	0
Methylene chloride	25	7	3	7	5.42	5.83	*	4
Tetrachloroethene	25	2	2	21	11.5	0.86	*	2
Toluene	25	1	5	5	5	1,000	*	0

Notes:
ARAR - applicable or relevant and appropriate requirement
µg/L - microgram per liter
— - not applicable
* - background established as 0

7.2.1 Surface Soils

Ten surface soil samples were collected in each of three potentially impacted areas at Site C-East. These areas are identified with the following designations:

- A – a leachate pit identified in the current situation report (Hart Crowser 1989)
- B – the former leachate pit that had been disturbed by road construction
- C – an area suspected of containing contaminated fill material returned from Site C-West

The following findings are presented for surface soils by class of analytes.

Metals. No metals concentrations exceed screening criteria.

Organic Compounds. One ordnance compound, 9 SVOCs, and 10 VOCs were detected in surface soils at Site C-East (Table 13). None of these compounds exceeded screening criteria.

No pesticides or PCBs were detected in Site C-East surface soils.

7.2.2 Subsurface Soils

Nine soil borings were drilled by using hollow-stem auger methods during February 1992. Three soil borings were drilled in each of the three identified disposal areas. Samples were collected by using a 2-inch split spoon sampler. At Site C-East, soil boring samples were taken continuously for visual analysis. Four samples were collected from most boring for chemical analyses. Thirty-six samples were selected, based on stratigraphy encountered.

The following findings are presented for subsurface soils by class of analytes.

Metals. Beryllium and manganese routinely exceeded screening in most geologic formations. Antimony exceeded screening criteria in the Vashon Till.

Organic Compounds. All VOCs detected were below screening criteria.

SVOCs detected in subsurface soils include benzo(a)pyrene, bis(2-ethylhexyl) phthalate, and di-n-octylphthalate. Benzo(a)pyrene was primarily detected in CE-MW29, CE-MW31, and CE-MW35 between 35 and 82 feet. Benzo(a)pyrene detections were in CE-MW31 at 60, 70, and 80 feet, which correspond to the acetone, 2-butanone, and methylene chloride detections found in this well at these depths. The benzo(a)pyrene detection locations in CE-MW29 also correspond to the acetone, 2-butanone, and methylene chloride detections for this well at depths of 35 and 40 feet. Benzo(a)pyrene was also detected in conjunction with acetone and 2-butanone at a depth of 60 feet at CE-MW35. There was one shallow (14 to 15 feet) detection of benzo(a)pyrene at CE-SB01, which is within the suspected fill area. All benzo(a)pyrene detections exceeded screening criteria, with a maximum concentration of 1.3 mg/kg.

7.2.3 Groundwater

One single well and four well clusters were installed at Site C-East (Figure 5). The single well, CE-MW26, was installed upgradient of the site. This well and existing well C-MW22 were used to assess the upgradient characteristics of Site C-East. Well C-MW22 was screened in the perched aquifer; well CE-MW26 was screened in the upper portion of the shallow aquifer.

Wells CE-MW27, CE-MW28, and CE-MW29 were installed downgradient of the fill material area. The wells were screened in the perched aquifer and the upper and lower portions of the shallow aquifer, respectively.

The three remaining well clusters were placed downgradient of the suspected leachate pits. Screens for CE-MW30 and CE-MW32 were installed in the upper portion of the shallow aquifer; screens for CE-MW31 and CE-MW33 were installed in the lower portion. The screen for CE-MW34 was installed in the perched aquifer, the screen for CE-MW35 was installed in the upper portion of the shallow aquifer, and the screen for CE-MW36 was installed in the lower portion of the shallow aquifer.

Existing monitoring wells C-MW01 through C-MW03 and C-MW12 through C-MW24 were used to supplement data obtained from newly installed wells at Site C-East. C-MW21, C-MW24, C-MW22, and C-MW18 were screened in the perched aquifer. C-MW13, C-MW17, C-MW19, C-MW20, and C-MW23 were screened in the upper portion of the shallow aquifer and C-MW01, C-MW02, C-MW03, C-MW12, C-MW14, C-MW15, and C-MW16 were screened in the lower portion of the shallow aquifer. Monitoring wells C-MW01 through C-MW03 and C-MW12 through C-MW18 do not

meet current regulations for monitoring wells, as defined by WAC 173-160. They were sampled during the first round of groundwater sampling, in accordance with the work plan. The data from these wells were used to help characterize the site, but were not used for risk evaluation or final decisions on site remedial action. Monitoring wells C-MW19, C-MW20, C-MW21, C-MW22, C-MW23, and C-MW24 meet current requirements for groundwater monitoring wells and were sampled. Data from these wells were combined with data from newly installed monitoring wells to provide information on the perched, upper shallow, and lower shallow aquifers.

The following are the findings for groundwater sampling by level and class of analyte.

Metals. Metals results are presented below.

Perched Aquifer. Results for dissolved metals are compared to screening criteria in Table 22. Antimony, arsenic, manganese, and thallium exceeded these screening criteria. Turbidity was measured in excess of 200 NTU in many samples. Metals in the perched aquifer are generally comparable to background concentrations.

Shallow Aquifer. Results for dissolved metals are compared to screening criteria in Table 23. Arsenic, lead, manganese, and nickel exceeded these screening criteria. Turbidity was measured in excess of 200 NTU in many samples. Metals concentrations in the shallow aquifer are generally comparable to background conditions.

Organic Compounds. Organic compound results are presented below.

Perched Aquifer. VOCs detected in the perched aquifer were acetone, benzene, 1,1,1-trichloroethane, methylene chloride, and tetrachloroethene (PCE). PCE and benzene were detected once at concentrations that exceeded screening criteria. PCE was widely detected in surface and near-surface soils at Site C-East, including the Pit A area.

Bis(2-ethylhexyl) phthalate is the only SVOC detected in the perched aquifer above screening criteria. It was detected in monitoring wells C-MW21 (in the vicinity of Pit A) and CE-MW24.

Otto fuel, 2,4-DNT, 2,6-DNT, RDX, and 2,4,6-TNT were detected in the perched aquifer. All ordnance compounds were detected below screening criteria.

Shallow Aquifer. VOCs detected in the shallow aquifer are shown on Table 23. Methylene chloride was detected at concentrations above screening criteria in monitoring wells CE-MW26, CE-MW30, CE-MW33, and CE-MW35. Methylene chloride was widely detected in subsurface soils within the Vashon Advance Outwash at Site C-East. PCE was detected twice at Site C-East; both detections were above screening criteria.

Six SVOCs were detected in the shallow aquifer. Bis(2-ethylhexyl) phthalate was the only SVOC detected in the shallow aquifer at concentrations above screening criteria.

Ordnance compounds detected, all below screening criteria, were RDX, Otto fuel, and 2,4,6-TNT.

Methoxychlor was the only pesticide detected at Site C. It was detected in monitoring well CE-MW30 at a concentration below screening criteria.

8.0 SUMMARY OF SITE RISKS

The baseline risk assessment analyzes current and potential future risks for a site and may be used to assist in evaluating whether remedial action is needed. The identification of the chemicals of concern, exposure assessment, toxicity assessment, and risk characterization are the primary components in a baseline risk assessment. The evaluation presented herein indicates the type of risks that could potentially result, if no remedial action is taken at OU 4. This section of the ROD reports the results of the baseline risk assessment conducted for this site.

Both human health and ecological risk assessments (RAs) were performed for OU 4 to determine the potential risks associated with chemicals identified at the site. The human health assessments were conducted in accordance with EPA's *Risk Assessment Guidance for Superfund*, Volume I: *Human Health Evaluation Manual (Part A), Interim Final* (U.S. EPA 1989b), EPA's *Supplemental Risk Assessment Guidance Region 10* (U.S. EPA 1991a), and the *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (U.S. EPA 1991b). The ecological risk assessment followed the latest federal guidance. The RA methods and results are summarized in the proceeding sections.

8.1 HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment evaluated potential risks associated with exposure to chemical contaminants from OU 4. All chemicals that were detected at least once were considered in the risk assessment. An initial screening step was performed that compared the maximum detected concentration of chemicals in soil and groundwater with site-specific background concentrations (inorganics only). Only those chemicals that exceeded background were carried through the quantitative risk assessment. These chemicals are considered to be chemicals of potential concern, or COPC. Risks from naturally occurring inorganics detected at background sampling locations were also calculated.

The assessment considered potential exposure to chemicals in groundwater, surface water, soil, and sediments. Risks for current and future exposures were evaluated. The current exposure scenario evaluated on-site workers; the future exposure scenario addressed on-site workers and hypothetical future residents. Inhalation of volatile chemicals released into indoor air while showering was evaluated for future residents. Potential exposures to the perched aquifer were evaluated as surface water because the perched aquifer is too shallow for well development and seeps out of the ground in several places.

8.1.1 Exposure Assessment

The purpose of the exposure assessment is to quantify contact with COPC identified at the site. This is accomplished by identifying the exposure media, potentially exposed populations (based on current and future land use), the routes of exposure, and quantification of human intake of chemicals. The populations, media, and routes of exposure that were evaluated for each area are discussed below.

Exposed Populations. Current and potential future land uses were considered in identifying potentially exposed on-site populations for OU 4. These potentially exposed populations include current workers, future workers, and future residents. Risks were calculated for both average exposures and for a "reasonable maximum" exposure (RME). The RME exposure scenario corresponds to the highest plausible degree of exposure that may occur at the site.

Exposure Media and Pathways. Because of the similar nature of the sites at OU 4, the same media were evaluated for each of the different areas. The media that were

quantitatively evaluated in the human health risk assessment include soil, groundwater, surface water, and sediment. Although a limited number of sediment samples were collected at the site, these sediments did not significantly differ from native soils and were evaluated in the risk assessment as if they were soil samples.

Although residential use of groundwater was evaluated, there is currently no residential development at OU 4 and these exposures are strictly hypothetical. Risks from residential use of filtered and nonfiltered groundwater were evaluated.

The following pathways were evaluated for each medium of concern:

- Soil/sediment: Ingestion and dermal contact (current and future scenarios)
- Groundwater: Ingestion and inhalation of volatiles (future scenario only)
- Surface water: Dermal contact (current and future scenarios)

Exposure-Point Concentrations. Exposure-point concentrations (EPCs) are those concentrations for each chemical to which an individual may potentially be exposed for each medium at the site. EPCs for the average exposure scenario were based on the arithmetic mean concentration for site chemicals. EPCs to the RME scenario were based on the 95 percent upper confidence limit of the arithmetic mean (95 percent UCL). EPCs were calculated for all chemicals which exceeded their background concentration. Chemical intakes for each exposure pathway were calculated by combining the EPCs with other exposure parameters such as water ingestion rates, inhalation rates, soil ingestion rates, dermal absorption rates, body weights, and exposure frequencies and durations in accordance with EPA guidance. Default exposure parameters recommended by EPA were used to evaluate exposure to soil and groundwater; site-specific parameters were developed for surface water exposures.

8.1.2 Toxicity Assessment

The purposes of the toxicity assessment are (1) to weigh the available evidence regarding the potential for chemicals to have adverse effects on exposed individuals (i.e., hazard identification) and (2) to provide a quantitative estimate of the relationship between the magnitude of exposure and the likelihood or severity of adverse effects (i.e., dose

response assessment). Toxicity values are derived from epidemiological or animal studies, to which uncertainty factors are applied (to account for variability among humans and for the use of animal data to predict effects on humans). The sources for toxicity values for chemicals at OU 4 are EPA's Integrated Risk Information System (IRIS) database (U.S. EPA 1993) and the Health Effects Assessment Summary Tables (U.S. EPA 1992a and 1992b).

Slope factors (SFs) have been developed by EPA for estimating excess lifetime cancer risks associated with exposure to potential carcinogens. SFs are expressed in units of $(mg/kg\text{-}day)^{-1}$ and are multiplied by the estimated daily intake rate of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the SF. Use of this approach makes underestimation of the actual cancer risk highly unlikely.

Reference doses (RfDs) have been developed by EPA for evaluating the potential for adverse health effects associated with exposure to noncarcinogenic chemicals. RfDs are expressed in units of mg/kg-day and are estimates of acceptable lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals of concern from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) are compared with the RfD.

Toxicity values are only available for the oral and inhalation pathways. EPA has not published toxicity values for evaluating the dermal pathway. Oral toxicity values were used to evaluate dermal exposure in accordance with EPA recommendations.

Because of its unique toxicity, lead does not have a verified reference dose; instead, EPA recommends an alternative approach to evaluating lead toxicity. This approach involves using EPA's LEAD 5 biokinetic model (U.S. EPA 1991) to estimate blood lead levels resulting from multipathway exposures. The results of this model are used to determine whether the lead present in different media pose a potential risk to future residents at the site.

8.1.3 Risk Characterization

The risk characterization integrates the information developed in the toxicity assessment and exposure assessment to develop carcinogenic and noncarcinogenic risks. The National Contingency Plan recommends an acceptable target cancer risk range of 10^{-6} to

10^{-4} for Superfund sites. Chemicals with cancer risks greater than 10^{-4} require further evaluation and remedial action. In this section, only those chemicals (or a combination of chemicals in the same media) with a cancer risk greater than EPA's acceptable risk range will be discussed.

A noncarcinogenic risk (a hazard index greater than 1.0) indicates that exposure to a site chemical exceeds the acceptable exposure level, as defined by the reference dose, and may present a potential health threat.

For inorganic compounds that have been identified as chemicals of concern, a comparison with background concentrations was conducted to determine the contribution that naturally occurring levels may make to site risks. Risks associated with background levels of chemicals were also calculated. (The complete range of chemicals in different media at the site is presented in the final RI and is part of the administrative record.)

Tables 24 through 30 present noncancer and cancer risk summaries for each area at OU 4. Risks that exceed EPA's acceptable levels were found only for the future resident scenario and are attributable to background levels of inorganic compounds. Risks are presented for groundwater; however, as discussed previously, these risks are hypothetical because there are no on-site residential receptors that use the groundwater. Risks from exposure to lead were evaluated by using the LEAD 5 biokinetic model recommended by EPA. No significant risks for lead were found at C-East or C-West.

Summary of Risks for Site C-East. The chemicals associated with the majority of the excess risks for Site C-East are presented in Table 24. These chemicals include 1,1-dichloroethylene, tetrachloroethylene, benzo(b)fluoranthene, bis(2-ethylhexyl) phthalate, and chrysene in groundwater.

The total hazard index and the cancer risk for all pathways in each scenario for Site C-East are shown in Table 25. The hazard index and cancer risk associated with naturally occurring background conditions are shown in Table 26 for comparison. Risks associated with background levels of inorganics were generally equal to or greater than on-site risks for the same chemical.

The excess noncancer hazard index and cancer risk for current and future populations at Site C-East are shown in Table 27. The excess risks shown in Table 27 do not include inorganics in groundwater, which were attributed to naturally occurring conditions and not related to previous human activities at the site.

Table 24
Site C-East—Human Health Risks and Chemicals of Potential Concern

Chemicals of Potential Concern	Hazard Index RME Resident	Carcinogenic Risk RME Resident
1,1-Dichloroethylene	< 0.1	1 in 110,000 (9.2×10^{-6})
Tetrachloroethylene	< 0.1	1 in 380,000 (2.6×10^{-6})
Benzo(b)fluoranthene	< 0.1	1 in 670,000 (1.5×10^{-6})
Bis(2-ethylhexyl) phthalate	< 0.1	1 in 1,000,000 (1×10^{-6})
Chrysene	< 0.1	1 in 770,000 (1.3×10^{-6})

Table 25
Site C-East—Total Hazard Index and Cancer Risk

Exposure Pathway	Hazard Index	Cancer Risk
Future Residential Scenario		
Groundwater ingestion	0.9	1 in 6,700 (1.5×10^{-4})
Surface water dermal contact	<0.1	1 in 5,000,000 (2.0×10^{-7})
Groundwater vapor inhalation	<0.1	1 in 430,000 (2.3×10^{-6})
Soil ingestion	0.1	1 in 140,000 (7.3×10^{-6})
Soil dermal contact	<0.1	1 in 28,000,000 (3.6×10^{-8})
Total pathways	1.1	1 in 6,300 (1.6×10^{-4})

Table 26
Background Hazard Index and Cancer Risk

Exposure Pathway	Hazard Index	Cancer Risk
Future Residential Scenario		
Groundwater ingestion	1.82	1 in 3,600 (2.8×10^{-4})
Soil ingestion	<0.01	1 in 770,000 (1.3×10^{-6})
Dust inhalation	NA	1 in 14,000,000 (7.0×10^{-8})
Total pathways	1.82	1 in 3,300 (3.0×10^{-4})

Table 27
Site C-East—Excess Hazard Index and Cancer Risk

Scenario	Hazard Index	Cancer Risk
Current Worker	less than 0.01	1 in 2,600,000 (3.8×10^{-7})
Future Worker	less than 0.01	1 in 270,000 (3.7×10^{-6})
Future Resident	0.1	1 in 63,000 (1.6×10^{-5})

Excess noncancer risk at Site C-East for all exposure scenarios is negligible. Excess cancer risk for the future residential scenario (the most conservative) is 1 in 63,000 (1.6×10^{-5}). All excess risks associated with Site C-East are within EPA's acceptable risk range for both carcinogens and noncarcinogens.

Site C-West. There are no chemicals of potential concern for excess risk at Site C-West. Naturally occurring inorganics in groundwater contributed to the majority of total site risk.

The total hazard index and cancer risk for all pathways in each scenario for Site C-West are shown in Table 28. The hazard index and cancer risk associated with naturally occurring background conditions are shown in Table 26 for comparison. Risk associated with background levels of inorganics were generally equal to or greater than on-site risks for the same chemical.

The excess noncancer hazard index and cancer risk for current and future populations at Site C-West are shown in Table 29. The excess risks shown in Table 29 do not include inorganics in groundwater, which were attributed to naturally occurring conditions and are not related to previous human activities at the site.

Excess noncancer risk at Site C-West for all exposure scenarios is negligible. Excess cancer risk for the future residential scenario is 1 in 590,000 (1.7×10^{-6}). All excess risks associated with Site C-West are within EPA's acceptable risk range for carcinogens and noncarcinogens.

Table 28
Site C-West—Total Hazard Index and Cancer Risk

Exposure Pathway	Hazard Index	Cancer Risk
Future Residential Scenario		
Groundwater ingestion	0.8	1 in 11,000 (9.1×10^{-5})
Surface water dermal contact	<0.1	1 in 15,000 (6.6×10^{-5})
Groundwater vapor inhalation	<0.1	-
Soil ingestion	0.1	1 in 100,000 (9.7×10^{-6})
Soil dermal contact	<0.1	1 in 12,000,000 (8.2×10^{-8})
Total across pathways	0.9	1 in 10,000 (1×10^{-4})

Note:
- = not available

Table 29
Site C-West—Excess Hazard Index and Cancer Risk

Scenario	Hazard Index	Cancer Risk
Current Worker	less than 0.01	1 in 450,000 (2.2×10^{-6})
Future Worker	0.002	1 in 1,200,000 (8.3×10^{-7})
Future Resident	0.20	1 in 590,000 (1.7×10^{-6})

8.1.4 Uncertainty

Some degree of uncertainty is associated with each step of the risk assessment. Important sources of uncertainty are discussed below.

Toxicity Assessment. There are numerous uncertainties associated with the approaches used to develop toxicity criteria (e.g., differences in study design, species, sex, and route). The magnitude and direction of uncertainty associated with the toxicity values for most chemicals are unknown. The EPA has noted, however, that the cancer slope for arsenic is conservative and may overestimate the actual risk attributable to arsenic.

As discussed in the toxicity assessment, oral toxicity values have been used for evaluating dermal exposures. The magnitude and direction of uncertainty associated with this approach are unknown.

Exposure Assessment. Most of the exposure assumptions used in the risk assessment are default values recommended by EPA. These values are not site-specific and are intended to be conservative. They are used to ensure that site risks are not underestimated. Actual exposures to site chemicals could be substantially less.

Because the groundwater is not currently used, the risks from ingestion of groundwater are hypothetical; therefore, although the groundwater was evaluated to calculate a worst-case scenario, the result is an overestimation of total site risk.

Risk Characterization. Some uncertainty is associated with the summation of risks for multiple chemicals. For example, not all noncarcinogenic chemicals have toxic effects on the same organ; therefore, combining individual chemical noncancer risks may yield a conservative estimate.

8.2 ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment for OU 4 is presented qualitatively rather than quantitatively because of the disparities in the quality of habitats at the sites and adjacent areas and the lack of data for the adjacent areas.

Sites C-East and C-West are in an area that has been subject to anthropogenic disturbances, which have modified site ecology. The area surrounding and encompassing Site C is in various stages of revegetation caused by logging, homesteading, and past and current Naval activities.

The wetland area on the west portion of Site C-East is characterized by saturated or near-saturated soil for most of the year. During the wet season, it may provide habitat for aquatic invertebrates and amphibians; however, a viable fish population is unlikely because of the seasonal water regime. Therefore, the wetland area is being evaluated strictly for its potential effect on terrestrial species.

A coniferous forest dominated by Douglas fir occupies the area east of Pogy Road. A deciduous forest dominated by red alder, with an understory dominated by sword fern,

occupies the wetland south of the Darter Road and Flier Road intersection. The wetland was delineated by SUBASE, Bangor personnel in 1991 and was determined to be a jurisdictional wetland. The wetland area is a shallow depression that collects surface water runoff and groundwater seepage from the perched aquifer. It is characterized by saturated or near-saturated soil for most of the year. Standing water occurs only during significant surface water runoff. When there is no surface water runoff, groundwater from the perched aquifer and underdrains continues to saturate the soil in the wetland area.

The triangular portion of Site C-East that lies between Flier, Darter, and Pogy Roads is covered with a limited variety of plant species. This area was cleared of trees and is dominated by Scotch broom.

The overstory of Site C-East west of Flier Road consists of a mix of coniferous and deciduous tree species. The west portion of Site C-East, near the intersection of Flier and Pogy Roads, is primarily dominated by Douglas fir interspersed with western red cedar and grand fir. The understory is dominated by sword fern.

Building 7700 and the asphalt-covered area surrounding the building occupy most of Site C-West. The habitat west of Building 7700 is a disturbed area dominated by Scotch broom and has been cleared to provide a right-of-way for transmission lines that cross Hunter's Ravine. The area south of Building 7700 is predominantly covered with Douglas fir, while the area east of Building 7700 is predominantly covered with red alder. Sword fern dominates the understory in areas south and east of Building 7700.

COPCs were identified from the soil, sediments, surface water, and perched groundwater data for each site. Identification was based on the following factors:

- Compliance with quality assurance/quality control guidelines
- Comparison with site background concentrations
- Consideration of environmental distribution and nutritional status of inorganic chemicals in soil

Soil data were screened to eliminate inorganic chemicals whose detected concentrations were less than background values. Background surface soil concentrations for each metal were derived from background locations SS-BG1 through SS-BG10, using Ecology

guidance (Ecology 1992). Inorganic chemicals whose maximum concentration exceeded background were identified as COPCs; however, inorganic chemicals that exceeded background concentrations but are ubiquitous minerals or nutritionally essential salts (e.g., aluminum, calcium, iron, magnesium, potassium, and sodium) were identified as COPCs when the maximum site concentrations were at least 10 times the respective background concentrations. This site-to-background factor was used in recognition of the toxicological nature and relatively wide tolerances to nutritionally essential trace elements. Potential toxicity associated with nutritionally essential elements occurs when chemical intake is too low or too high. Between these levels, most organisms are able to tolerate a wide range of chemical intake and to metabolically regulate mineral levels without symptoms of toxicity.

All organic chemicals detected in surface water were considered COPCs. Inorganic chemicals detected in surface water were considered COPCs, if they were also listed as COPCs in surface soil and sediment.

The overall emphasis of the environmental evaluation is on the potential chemical exposure to adjacent habitats that may result from off-site transport of chemical contaminants and on the potential exposure of organisms that may be sporadic and transitory visitors to the sites. The qualitative nature of this ecological evaluation is further dictated by the high degree of uncertainty in the frequency and duration of exposure to biota whose presence at these sites is probably sporadic and transitory.

The initial selection of COPCs for terrestrial habitat at Site C was considered conservative. Six inorganic chemicals were deleted as COPCs in soils on the basis of simple background comparisons. All remaining chemicals were retained as COPCs and evaluated further. The data evaluation included perched aquifer groundwater samples as potential surface water sources, which represents a conservative approach to the evaluation of surface water ingestion by terrestrial receptors. Because of the high uncertainty associated with the presence and concentration of tentatively identified compounds (TIC), these data were not included in the ecological assessment (EA).

A screening-level EA was used to evaluate potential risks to terrestrial receptors (including the Townsend's vole, the black-tailed deer, coyote, and great horned owl) from chemicals detected in soil, sediment, surface water, and perched groundwater. Exposure of terrestrial receptors representing several trophic levels was estimated by multiroute exposure modeling. Hazard quotients (HQs), which are the ratio of the estimated exposure to a toxicity reference value, were used to evaluate potential risks. HQs

greater than 1 but less than 10 indicate the potential for an adverse effect to occur, while HQs greater than 10 indicate a probable concern.

The conclusions of the EA are that COPCs at Site C-East and C-West pose negligible risks to the deer and predator species (coyote and great horned owl). HQs exceeded 1, but were less than 10, for a vole exposed to RME concentrations of lead and vanadium at Site C-East and manganese and vanadium at Site C-West, suggesting a low potential for substantial adverse effects. Qualitative evaluation of these HQ values compared with background concentrations and available toxicity information suggests that potential risks for vole populations exposed to lead, manganese, and vanadium are negligible.

9.0 DESCRIPTION OF ALTERNATIVE 1, NO ACTION

9.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The primary goals associated with the overall protection of human health and the environment are to prevent unacceptable risks from ingestion or dermal contact with groundwater. At Site C, the human health and environmental risk levels posed by all media are within EPA's acceptable risk range. These goals are achieved by the no-action alternative.

Screening criteria were previously defined in Section 8.0. Risk levels associated with Sites C-East and C-West do not require remedial action under CERCLA. There are exceedances of the MTCA cleanup goals in both soils and groundwater. These exceedances are infrequent for organic compounds and more common for inorganics, especially metals in groundwater. These concentrations also exceed some maximum contaminant level (MCL) from the Safe Drinking Water Act. The observed levels of inorganics in groundwater are from natural conditions and are not related to human activities at the sites. This alternative would not reduce these exceedances of risk-based screening levels.

9.2 NEPA COMPLIANCE

For NEPA compliance, wetlands, floodplains, historical preservation, and rare or endangered species must be addressed. Sites C-East and C-West are not in a floodplain,

but do contain wetlands. No historical preservation has been issued for the site; the eagle is the only endangered species known to inhabit SUBASE, Bangor.

10.0 EXPLANATION OF SIGNIFICANT CHANGES

The proposed plan was released for public comment in November 1993. The proposed plan identified no action as the preferred alternative. The Navy, EPA, and Ecology reviewed all written and verbal comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the remedy, as it was originally identified in the proposed plan, were necessary.

11.0 REFERENCES

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ATTACHMENT 1

RESPONSIVENESS SUMMARY

1.0 SUMMARY OF PUBLIC COMMENT

The comments received by the Navy concerning the proposed plan were an oral comment raised at and responded to during the public meeting. These two comments were made by Jim Speer and Al Starcevich from Olympic View Environmental Review Council (OVERC). The public meeting was recorded on a transcript. which is available at the information repositories.

Summary of Comment: Two members of a community organization OVERC stated that the organization had reviewed technical documents regarding the proposed plan. OVERC agreed with the proposed plan and felt the Navy had done a good job during the investigations and concurred that no action is warranted at Sites C-East and C-West. The speakers thanked the Navy for the opportunity to participate in the process, and Mr. Starcevich asked that during future public meetings OVERC be recognized for its involvement.

2.0 RESPONSE TO COMMENT

Response: The Navy appreciates the comment regarding the quality of the documents and investigations. The Navy is committed to citizen participation during all of these investigations and encourages and values public participation in this process. In regards to the presentation of the community organization, OVERC, the Navy asked the organization to briefly describe its function. The community organization then presented its role in the public involvement.

The Navy concurs and will acknowledge official representatives from OVERC and, in order to be fair, will ask any other official representatives from other organizations to introduce themselves.